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PREVENTIVE MEDICINE IN RELATION TO THE PUBLIC HEALTH.

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BEING

LECTURES AND ADDRESSES DELIVERED AT ST. THOMAS'S HOSPITAL

AND ELSEWHERE.

REVISED BY THE AUTHOR.

LONDON:

SIMPKIN, MARSHALL, AND CO.

1877.

PREFACE.

THE following Lectures were delivered to the Students of St. Thomas's Hospital during the Summer Session of 1876. They are published at the request of numerous friends, in the confident hope that they will be found useful to those who are striving to grapple with disease, so as to assist them to diminish its gravity and impede its incidence in particular districts. They are suggestive as to further progress in disease obstruction, rather than exhaustive in their character, and are intended to direct the workers in sanitary science as to the lines they should pursue, and are not in any way to be taken as complete. A paper is also included on the power of soil, air, and vegetation combined to purify sewage, the substance of which was read to the Society of Medical Officers of Health in 1875. Some practical observations on the management of sewage farms are also appended, together with a portion of the address on Public Medicine, which was delivered at Sheffield to the British Medical Association on August 4th,

1876. The subjects there dealt with are so connected with the matters touched upon in the Lectures, that I have republished them, with such alterations and revision as the progress in science points out as being necessary. This Address forms, in a great measure, a full *resumé* of the preceding papers. Some recapitulation has been unavoidable; this in a work like the present cannot be looked upon as a fault, since Sanitarians, and Medical Officers generally, know only too well how often they have to iterate and reiterate the same fact before any impression can be made, either upon the public at large, or their representatives, the Local Authorities. I have not hesitated to take advantage of the observations of others; and, although I have generally mentioned the name of the author, I have not encumbered the work with notes of reference to the works themselves, believing that the student will have no difficulty in finding the passages to which reference is made, if he wishes to do so. I have to thank Mr. W. T. Marchant for the assistance he has been to me in editing the Lectures, and also for compiling a useful index to the volume.

Croydon, September, 1877.

LECTURES
ON
PREVENTIVE MEDICINE.

INTRODUCTORY ADDRESS.

Introduction — Pioneers of Preventive Medicine — John Simon — Dr. William Farr — Prevention Better than Cure—Quackery the Result of Ignorance —Evils Reproduce Themselves—Medical Officers of Health — State Medicine Examinations — Vital Statistics the Basis of Correct Knowledge—Quetelet's Axioms—Births and Deaths, Ratio of—Errors of Registration—Zymotic Diseases, Classification of—Factors of Disease—Germs—Resting Spores and the Potato Disease—Diphtheria, Causes of—Cryptococci—Popular Ignorance in Mistaking Cause for Effect—Cholera, Mr. Netten Radcliffe's and Mr. Simon's Opinions on—Conditions Essential to Health—Isolation—Suggestions of the Society of Medical Officers of Health—Propagation and Development of Contagia—Dr. Baxter's Researches —Albuminoid Matter—Disinfectants, Popular Fallacies concerning—Comparative Powers of Disinfectants on Disease Germs.

Gentlemen of St. Thomas's Medical School, —I stand here to-day in a somewhat peculiar position. Having no status in this great hospital, either as a member of the staff, or as one of the recognised lecturers in this school, I am yet permitted to address you upon that which, in a national sense, may be considered as one of the great ques-

tions of the day. Not to the same extent, perhaps, as it was nearly three years ago, when the Prime Minister declared "*Salus populi suprema est lex*," and the then Leader of the Opposition unfurled his flag with the inscription, "*Sanitas sanitatem omnia sanitas.*" The party cries of our political leaders have served their purposes, and, in a Parliamentary sense, at this time, sanitary work is at a discount. "Harassing legislation," as it has been called, possesses verylittle favour with Members of Parliament on either side of the House; yet the wave of progress which receded after the spasmodic efforts of 1873 is advancing again with greater force. The question as to how the health of the people can be secured is forcing itself upon the attention of all classes of Her Majesty's subjects. It is only natural that the natives of a country whose first enquiry in ordinary conversation is a desire to know how you are, should be foremost in the prosecution of sanitary work. It is consequently only natural that a great hospital like St. Thomas's should have upon its staff those who have done the most in directing attention to this great subject, and that the staff should glory in the name of the great apostle of preventive medicine, John Simon, a worthy representative of a noble line of health-preservers. Still, the position I occupy is in many ways a peculiar one; for, following the footsteps of my honoured teacher "*sed longe intervallo*," I propose to point out how such measures are to be certainly secured as will assist to abolish a large

portion of the ordinary work of the general practitioner, and to diminish the calls which are constantly made upon him for professional services, by the prevention of at least one-half the common ailments of daily life. My hearers need not, however, be dismayed at this statement, because no one now present will live to see the consummation of the thought. Nevertheless, the change which is looming in the future with regard to public health may be nearer than the most sanguine sanitarian anticipates.

An enquiry cannot be instituted as to how those functional disturbances that arise from defective sanitary arrangements shall be effectually prevented—those avoidable diseases which produce a very large proportion of a family medical adviser's daily work be abolished—without some people considering it to be suicidal policy, resembling that which the Japanese are said to adopt when they commit what is called the "Happy Dispatch." It might be supposed, if we were to be entirely guided by analogy or precedent, that medical men, of all persons, would be disinclined to listen to proposals similar to those which I am about to make, and that a cry would be set up among us with as much vehemence as one was in the days of the Apostle Paul—"Great is Diana of the Ephesians!" Indeed, a similar cry is daily raised at the present time, when some vested interest in the right to spread disease and death is assailed, or some private means of damaging

other people's health is questioned. It is not raised by us as a profession, but by those who decline to see the bearing of a given case upon public health as against their pecuniary advantages. Thank God, such a spirit cannot be generally looked for in the minds of those whose duty it is to minister to and relieve the ills which afflict humanity. Our great aim as a profession from time immemorial has been to cure disease if it be established, but in more recent times our still greater aim is to prevent disease establishing itself at all, if it be possible. The value of the precept that prevention is better than cure is fully recognised. The general public, however, will not entirely credit us with singleness of purpose, and scarce give credence to the idea that we are in earnest in this matter, although the thinking portion of the world regard our exertions in a proper light. I well recollect the laughter which was raised in a Parliamentary Committee on an occasion in which I was giving evidence in favour of a Sanitary Bill, on suggesting that it would by its operations tend to diminish materially the work of the doctors. The learned counsel asked whether I was in earnest in this. I told him that I belonged to a class who devoted much of their time to the prevention of disease. The counsel then asked, in a sly kind of way, but without waiting for an answer, "What would be thought of Queen's Counsel if they belonged to an association for diminishing or preventing appeals to the tribunals of the law?"

The belief, however, is now becoming popular that a very large percentage of ordinary diseases is quite preventible. It is supposed that 50 per cent. of all the maladies which employ the time of the general practitioner would not arise if sanitary works were properly carried out, and the ordinary laws of Nature as to cleanliness obeyed. The duty of the family medical adviser is not only to instruct his patient in the way to get better of his disease, but also to tell him how to prevent the recurrence of similar attacks in the future. The public are becoming fully aware of this fact in consequence of the teaching of our profession, and they will be certain even to demand more assistance than we shall be able to afford. They are now enquiring most urgently to be saved from the infliction of those evils which they are assured, both by experience and analogy, can be prevented if proper means are adopted at the right time. The fact that a large portion of the members of our profession are uneducated in the laws of prevention does greatly tend to diminish our power in the State as a profession, and also gives an impetus to those forms of quackery which too often find favour with enquiring and reforming minds. These people see that serious errors are often made by medical men in the matter of prevention, and, losing confidence in their usual family adviser, they seek fresh advice from men of the world, who idealise and seek safety in specious platitudes rather than in accuracy of diction.

Hence -isms, -ologies, and -pathies often find favour because the orthodox practitioner has misdirected his patient on a point of simple prevention. The educated sanitary adviser must nevertheless be prepared for disappointment.

> "The devil was sick, the devil a saint would be;
> The devil was well, the devil a saint was he."

This is quite true of men, as it is reported to have been of the so-called Prince of the Dark Regions. But it is a truth which is partial only in its application; it has reference more to the conduct of those suffering from illnesses which arise from the pleasures of the table, the seductions of lust, and the results of idleness, than to the class of diseases which may be induced by causes about which I have the privilege of addressing you. These causes are more generally produced by the acts or neglect of others than by our own work, and we are much more severe upon them for neglect of duty than upon ourselves for our own *lâches.* These faults of omission and commission are now exciting great attention among all classes of people, and giving rise to indignant protests, which have to be attentively considered. You, gentlemen, as the future medical advisers of families, will be called upon to direct the persons who consider themselves to be pecuniarily aggrieved, as well as injured in health, as to how they should obviate similar results in the future.

The consideration of the causes of disease, to which I must confine myself, are those which are produced by the neglect of municipal authorities and the heads of families to provide for the wants of humanity, and also the removal of those evils which result from that neglect. The acts of an individual, a corporation, or a community may produce evil to others ; those who are liable to suffer being oftentimes ignorant of the dangers to which they are exposed until their effects have been manifested by a full development of disease, often in an epidemic form. The prevention of causes of these types of sickness is at all times a benefit rather than an injury to all classes of society, since it deprives them of no privilege that is worth retaining, of no right which is not followed in its exercise by a greater wrong; whilst the converse of the proposition—viz., the act which promotes public health also promotes public wealth, is a truism which is realised in a manner that it is not now within my province to prove.

We live in an age of progress. The changes which are taking place in the works of our profession are well marked. The sub-division of labour is now as much recognised in medicine as it is in every other profession or calling in life. The study of "State Medicine," as it is often called, is a speciality which is fairly conceded, and must be considered by all institutions which undertake to educate our students in

medical science. The various permissive measures which have been sanctioned by Parliament, and which have been materially promoted by evidence produced by men attached to this hospital—such as the late R. D. Grainger, and our own accomplished teacher, John Simon—have now resulted in the production of a compulsory measure, which renders it imperative upon local authorities to appoint Medical Officers to supervise and watch over the health of the inhabitants of every portion of the kingdom. The Medical Officers of Health at present sub-divide themselves into three orders of men. First, the Medical Officer of Health who devotes himself entirely to the duties of his office, and has, in consequence, barred himself from other professional work. This is the highly accomplished sanitarian and specialist who has the supervising of large areas, and the special consideration of those means by which disease can be prevented.

The second class of Medical Officers of Health are members of the Poor Law Medical Service, appointed by Boards of Guardians to alleviate the sicknesses which afflict the poor. These officials, being in immediate and early contact with State diseases, are called upon by the destitution authorities to advise as to the best means to be used for the arrest of epidemics, and they have generally to urge upon their local authorities the adoption of preventive measures.

The third class of Medical Officers of Health are

those who, not being in the Poor Law Service, yet take upon themselves the duties of Medical Officers of Health in addition to their ordinary private professional work. Some of the greatest of our sanitary authorities belong to the latter class of public officials.

From the nature of the work of a Medical Officer of Health, it must be apparent to all that those who are the least able to take care of themselves are those for whom the State must provide protection. Experience shows most clearly that the first brunt of an epidemic always falls upon the poor with the greatest violence. It is from the poor of a given district that infectious disease spreads to the upper classes. Hence it is both the duty of the State, and the interest of the wealthy classes, that the health of the poor should be supervised by a responsible and capable official; as the law now stands, he ought to know how to perform the work he undertakes. It follows, therefore, as a matter of course, that every man who undertakes to act as Medical Officer in attendance upon the poor should also know something of preventive medicine. Every man designing to enter the ranks of our profession may be called upon to act as Poor Law Medical Officer; and he will be certainly called upon at times to attend to the poor. The corollary arises, therefore, that every medical man ought to have a fair acquaintance with the laws which apply to the prevention of disease as well as of those means

which are best designed to cure it. He may determine, when he has become fairly enrolled in the ranks of our profession, that his *forte* is not prevention, yet none the less ought he to know the first rudiments of the science.

It becomes, therefore, a necessity that every man, whatever may be his intention as to future practice, should know how to keep air and water pure, how to get rid of the refuse of our towns, as well as to recognise the diseases which spring from corporate or individual action, or neglect in these matters. It may not be necessary for him to get up in detail the bearings of all the Acts of Parliament which relate to the foregoing subjects. It does not follow that he shall always have sanitary statistics ready at hand, or be perfectly acquainted with the effects of other climates than our own. He need not necessarily be up in the duties which devolve upon a Naval or Military Medical Officer, if he does not intend to enter those services. But every practising medical man ought to know how to advise his patients as to the three subjects upon which I have the privilege of speaking—viz., purity of air, of water, and the disposal of sewage. The consideration of these matters make up a large part of the sanitary work which will devolve upon the ordinary medical adviser, and it is with this latter branch of the profession that I have now to deal.

The progress which is being made in the direction of disease prevention is fairly marked by the

act of the Medical Council in desiring, and by that of the Universities in instituting, an examination in State Medicine, by means of which those who intend to compete for the best class of appointments as Medical Officers of Health—namely, those in which a man must devote himself entirely to the duties of his office—will have an opportunity of proving his fitness for that office. It becomes important, therefore, that medical schools should prepare their students for this examination. It would be wrong on the part of the authorities of St. Thomas's if they did not provide some instruction in the ground-work of sanitary science. The limited time, however, which is at my disposal will not allow me to pass in review all those branches of the subject which you will have to enquire into if you propose to obtain a certificate in State Medicine. The comprehensiveness of those branches is well shown by the list of subjects which a candidate is supposed to master, and in which he has to give proof of possessing a fair knowledge of before he is presented with his certificate.

They include the principles of chemistry; the methods of analysis (microscopical as well as chemical), both of air and water; the laws of heat; the principles of pneumatics, of hydrostatics and hydraulics, with especial reference to ventilation, water supply, drainage, construction of dwellings, and to sanitary engineering in general. They also include the Laws of the

Realm which relate to public health; a knowledge of sanitary statistics; the origin, propagation, pathology, and prevention of epidemic and infectious diseases; the effects of overcrowding, vitiated air, impure water, bad or insufficient supply of food, unhealthy occupations, and the diseases to which they give rise; the disposal of sewage, and character of nuisances which are injurious to health; the distribution of diseases, and the effects of soil, season, and climate upon densely-populated districts.*

To deal with all these subjects in a comprehensive manner would require ten times the number of hours which are at my disposal. I am, therefore, restricted to the consideration of those matters only which properly come within the cognisance of every general practitioner.

I do not attempt to define the term "State Medicine," or that which is considered to be represented by the term Public Hygiene. I wish I could conscientiously call it Sanitary Science. I

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* The General Medical Council, in their last meeting (May, 1877), drew up a scheme for the professional examination, both preliminary and final. Amongst other compulsory subjects, it was specially defined that the chemical examination should include Physical Chemistry, meaning thereby heat, light, and electricity; and the term Natural Philosophy should embrace a thorough knowledge of hydrostatics, pneumatics, hydraulics, and mechanics. These subjects of examination were suggested by Mr. John Simon, who stated truly that no professional man would be competent to discharge the duties of a Medical Officer of Health without he had a thorough knowledge of the subjects enumerated.

like that term best, but it is not more applicable to State Medicine than to curative treatment. Perhaps the term Preventive Medicine would be best. Both studies are in their infancy as exact sciences, so far as our knowledge stands at present; but the foundations for both are being laid, and these foundations will form the basis of scientific accuracy.

Every medical practitioner, wherever he may be placed, should know the rules which must be followed if he wishes to keep his own house healthy. I consider the individual house to be the unit of sanitary work, the place in which the first principles must be commenced; and a medical man's house should be the model for his patients, the first unit upon which he ought to practise if he determines that he will advise others. The science and practice of sanitation, like that of charity, should begin at home.

There are three heads regarding which he must be prepared to advise his patients, viz:—

(1) As to the character of the air.
(2) The water supply, both as to quantity, quality, and distribution.
(3) The disposal and utilisation of animal refuse.

Wherever the medical man may be placed, whether at home or abroad—whether he be among his own countrymen or foreigners, in the city or in the village—the consideration of these matters will be forced upon him, and he will be expected

to understand all the bearings of law and custom upon them.

Before considering each branch in detail, it will be requisite to put before you some of the evidence we possess as to the proof afforded us of the effects of impurity, and to tell you how we are able to determine with certainty the benefit or evil which results from purity or impurity respectively.

VITAL STATISTICS.

We are now able to approach the confines of truth upon some points from the evidence afforded by a careful study of "Vital Statistics." I am inclined to place Dr. William Farr, next to our own John Simon, as amongst the foremost of those who have fashioned a broad platform upon which we are gradually building some incontrovertible sanitary truths. The tables compiled by that eminent statistical authority have been of infinite service in dispelling some of the clouds which obscured our vision, and prevented a correct appreciation of many things which influence public health. To Dr. Farr belongs the credit of having initiated the work which he has carried on so satisfactorily for a long series of years, and by

means of which he has enforced the compulsory adoption of various hitherto permissive measures, which the presence of endemic diseases in certain localities seemed to require, by the substitution of the word *shall* for *may*.

A knowledge of "Vital Statistics" is as necessary to the Medical Officer of Health as is the compass to the mariner; he cannot know the actual bearing of sanitary work in a given district without it. The Registration Act of 1834 marks a starting point; to that we owe much of our power to deal with epidemics in a given place. At the same time, it is right to remember that at present our statistical tables are only approximations, not scientific facts.

The number of deaths in a given district bear no constant ratio to its healthiness or unhealthiness. It does not necessarily follow that the conclusions respecting the sanitary condition of a town or a country is correct because the ratio of mortality is low. There are many disturbing causes which have to be considered and eliminated, before a comparison of the death-rate with other places can be safely relied on as a correct indicator of the health of a particular district. This is irrespective of the character of the prevalent diseases. Still, the prevalence of a particular kind of disease in one place more than another, states a problem which is generally capable of solution when enquiry is judiciously directed, as to the causation of that special

disease, and the reason why it puts in an appearance there. Those who call in question the usefulness of "Vital Statistics," as at present tabulated, forget the law that errors occur in all things human; the errors themselves are capable of being eliminated, and their sources may easily be allowed for. That, indeed, is a part of "Vital Statistics" which the Medical Officer of Health is especially called upon to consider, and to be careful to allow for them before he draws any very positive conclusions as to the healthiness or otherwise of a given district.

You will have to consider the law of probabilities in all its bearings. According to that law, it may be that accidental causes, acting through a considerable period of time or over a considerable area, counteract each other. Let the disturbing influences be constant; let the data which form statistical tables be honestly collected; let them be taken from an extended area, and be sufficiently numerous, then the inferences drawn from the average will be a very fair approximation to the truth.

Every Medical Officer of Health ought to be acquainted with the rules which are ascribed to the Belgian statistician Quetelet, which he framed for general guidance in drawing deductions from statistical data. These rules are embodied in the four following axioms, which ought to be impressed upon the memory of everyone searching after truth by the aid of figures :—

RULES FOR GUIDANCE.

(1) Do not have pre-conceived ideas as to what the figures you are collecting are to prove.

(2) Do not reject figures which are contrary to expectations, because they are at variance with the expected average.

(3) Be careful to record all possible causes of an event, and do not attribute to one cause a result which may be due to a conjunction of several.

(4) Do not compare data which have nothing in common.

If all these points are kept in mind in dealing with statistical data, you will be able to assess the value to be given to the different tables which I will now put before you.

The tables set before you will indicate some of the laws, as well as the disturbing causes, which you must take into consideration. I need now scarcely describe how death-rates are calculated. It is usual to determine them by a reference to the number of deaths which have taken place in one year among each 1,000 persons living. The first table gives the vital statistics of the principal towns in the kingdom :—

Table I.

VITAL STATISTICS OF THE PRINCIPAL TOWNS IN ENGLAND IN ORDER OF DENSITY OF POPULATION.

Name.	Population per Acre.	Death-Rate.	Zymotic-Rate.
Liverpool . .	100.1	31.1	5.6
Glasgow . . .	90.3	31.1	6.4
Manchester . .	84.5	30.4	6.0
Birmingham . .	44.0	23.3	3.6
London . . .	46.3	24.2	4.5
Edinburgh . .	40.6	26.9	4.0
Hull . . .	38.0	24.1	2.8
Bristol . . .	44.0	24.2	2.0
Dublin . . .	33.1	25.4	4.4
Newcastle . .	25.5	28.0	6.0
Salford . . .	23.9	28.5	7.6
Leeds . . .	12.3	27.2	3.6
Sheffield . . .	14.0	26.5	4.6

The next shows the birth and death-rate in different kingdoms of Europe:—

Table II.

BIRTH AND DEATH-RATES IN EUROPEAN KINGDOMS PER THOUSAND.

	Death-Rate.	Birth-Rate.
England . . .	22.61	35.25
France . . .	23.63	26.26
Spain . . .	29.73	37.16
Austria . . .	30.84	39.86
Italy . . .	30.14	37.39
Prussia . . .	28.84	39.26

TABLE III.

DEATHS AMONG ONE HUNDRED THOUSAND BORN.

0 to 5 years	263.18
5 " 10 "	34.30
10 " 15 "	17.94
15 " 20 "	28.81
20 " 25 "	28.71
25 " 35 "	64.05
35 " 45 "	69.08
45 " 55 "	81.8
55 " 65 "	112.08
65 " 75 "	147.905
75 " 85 "	122.556
85 " 95 "	36.412
95 " 100 "	1.93
100	.223

You will see, also, that density of population upon a given area, although that itself has been thought sufficient to account for a high death-rate, yet it does not necessarily follow as a sufficient cause. Neither the death-ratio nor zymotic-rate need be in proportion to the population. In preparing these tables I have made use of the information contained in Dr. Farr's quarterly reports.

Then, again, you will see in Table III. that the proportion of deaths varies at different ages for males as compared with females in some localities, and differs from others—as in some parts of London, for instance. The annual average mortality also varies according to ages, in separate places.

Table IV.

THE ANNUAL AVERAGE MORTALITY PER THOUSAND LIVING OF MALES AND FEMALES IN ENGLAND AND WALES AT

Ages.	Males.	Females.
0 to 5	72.6	62.7
5 „ 10	8.7	8.5
10 „ 15	4.9	5.0
15 „ 25	7.8	8.0
25 „ 35	9.9	10.1
35 „ 45	13.0	12.3
45 „ 55	18.5	15.6
55 „ 65	32.0	28.0
65 „ 75	67.1	58.9
75 „ 85	147.1	134.3
85 „ 95	305.5	279.5
95 .	441.1	430.4

Table V.

RELATIVE FREQUENCY OF SOME DISEASES PER THOUSAND DEATHS IN ENGLAND (DR. FARR).

	Per 1,000.
Phthisis	108
Bronchitis	87
Atrophy and Debility . .	61
Old Age	55
Convulsions	52
Diarrhœa	45
Pneumonia	41
Violence	39
Whooping Cough . . .	28

TABLE VI.

DEATH-RATES PER THOUSAND IN LONDON FROM ALL CAUSES AT DIFFERENT PERIODS OF TIME.

Year.	Per 1,000.
1660 to 1680	80.0
1681 ,, 1690	42.1
1746 ,, 1755	35.5
1846 ,, 1855	24.9
1871	22.9
1875	22.5

In Table V. I have set out the relative frequency of various classes of diseases per 1,000 deaths. You may have a high death-rate and a high birth-rate; the latter naturally raises the former. They are disturbed, therefore, by the births of a given district, if that be high. A lying-in hospital may give a high birth-rate in a certain area, and, as a consequence, a high-death rate, because a definite number of children always die in the first days of their life. So, again, a country in which the families are comparatively small may have a lower death-rate than one in which large families predominate, for corresponding reasons, and yet the health of the district may be bad. Therefore, in drawing safe conclusions, the number of deaths must be compared with those of births. The sanitary condition of England is far superior to that of France and Austria, yet its average death-rate does not give its true position, as compared with those countries. England has an

average death-rate of 23.6, but the birth-rate of England is 35.25, as against 26.26 in France. This addition of nine more births per 1,000 in our country raises the healthiness of England, as compared with France, to a much higher position, if all the deaths of children in the first days of their life were struck out on each side. Mr. Ansell has published some valuable facts as to child mortality, which I may quote for your information. He shows us that, whilst in certain streets in Liverpool 90 per cent. of all the children born die before they reach the age of five, only 10 per cent. are lost among the children of peers of the realm; and, whilst 25 per cent. die among the children of all England, only 13 per cent. are lost among those born to the "Upper Ten."

It has been held that the high birth-rate is an effort of Nature to compensate for the excessive waste of life which is going on in large towns; and Dr. Farr says that wherever, from the combined effects of intemperance, dirt, overcrowding, bad ventilation, and bad drainage, the mortality is highest, there also the rate of births to population is also greatest. I do not, however, hold this view. It need not be that high death-rates have high birth-rates, for instances to the contrary are sufficiently numerous to show that it is no law of Nature, but that it is most probable that some of the causes—overcrowding, for instance—which lead to those high birth-rates have much to do with the high death-rates. The results

are more likely to be the consequences of a common cause than that of cause and effect. There are many other disturbing influences which will strike the attention of the careful observer, and which, when once noted, may be calculated for with precision if a little trouble be taken.

ZYMOTIC DISEASE.

The law of averages being well understood, we may direct our attention to the explanation, which will enable us to understand the indications which a death-rate indicates. We may find a given district always showing a high death-rate, as compared with some other place. We may ask—Why should Yorkshire always give a higher rate as compared with London, and why different localities in the Metropolis have very varying figures—localities which are large enough to exclude those disturbing causes to which I have already alluded? For an explanation of these circumstances, we must make an extended research, and enquire into the causes of death themselves. We group the deaths into a series of classes according to their alliances, and then get further information as to the state of health in a particular district. For instance, it is customary to call a certain class of diseases by the generic name of Zymotic, to class them together, and to consider them as a barometer which indicates the sanitary condition of a given area.

I shall follow this rule for the sake of convenience, premising that it is not one which has scientific accuracy about it at present, because its sum is the aggregate of observations made by a number of persons whose aim has not been to attain strict scientific accuracy, and who, in consequence, have not always returned their data upon correct bases. For instance, deaths due to measles are sometimes entered as having been caused by lung disease. Scarlatina may be registered as convulsions, enteric fever may be called meningitis, and *vice versâ*. Deaths due to non-specific forms of disease appear among the zymotic class, and errors of various kinds creep in, either by reason of the ignorance or the carelessness of the reporter; and a large number of the registered deaths have never been diagnosed at all as to the nature of the fatal disease.

Still, these classes of errors, when the data are taken from a large area, tend very much to correct themselves, and we may fairly take the figures given as approximating sufficiently near to the truth to enable us to draw tolerably accurate conclusions. Leaving out of consideration for the present all other causes of mortality, we may now enquire as to what is the general character which constitutes the zymotic class of diseases, for it is with those that I have most to do with. They are those which we regard as preventible. As set forth in the table, I have divided them into seven classes, according to their alliances. In

this country there are seldom more than seven or eight diseases that are sufficiently frequent to enable us to draw statistical deductions from their appearance in a given locality. The term *Zymotic* was first proposed by Dr. Farr, merely as a synonym for preventible. It is a useful term, and need not necessarily signify that which it would appear to indicate, viz., a fermentation, and therefore I retain it. I now present for your consideration a classification which I hope to make more clear as we proceed :—

CLASSIFICATION OF ZYMOTIC DISEASES.

CLASS 1.—Small-pox, cow-pox, chicken-pox, sheep-pox.
2.—Measles, influenza, exzema; epizootica, catarrh, whooping cough.
,, 3.—Scarlatina, puerperal fever, diphtheria, dengue, malignant pustule, erysipelas.
,, 4.—Typhus, plague, relapsing fever, spinal meningitis, cattle plague.
,, 5.—Diarrhœa, cholera, enteric fever, dysentery, intermittent fever.
,, 6.—Workhouse opthalmia, gonorrhœa, purulent opthalmia.
,, 7.—Glanders, farcy, strangles, syphilis.

You will observe that I have included in that table some diseases that are supposed to affect animals only, for reasons which I will not now stay to explain.

If, on examining the registrar's return from a given district, we find diseases of the zymotic class preponderating, we may fairly conclude that there

is some great sanitary defect in that locality. If we find typhus or typhoid, scarlatina, diarrhœa, diphtheria, or relapsing fever figuring to any extent in the list, we enquire whether these deaths are occasional only, or whether they have figured for any length of time; whether they are endemic or epidemic. A reference to Table I. on page 18 will show how they increase the death-rate in a given district.

Some of these diseases are occasional visitors only, their advent being heralded by the mischief they produce in the districts they may visit. Thus, the devastations of cholera, like that of an invading army, tells its own tale as it passes through the land. Such diseases come and go in a way which we try to explain, but our explanation is not yet expressed with that accuracy which a science requires. We predict an eclipse with certainty, but as to cholera, though it has been often prognosticated, the prophecies as to its advent have not always been fulfilled, because we have no correct means of ascertaining, and accurately estimating, the disturbing causes which interfere with its course. I mention cholera because it is an occasional visitor only in this country; but there are regions where it is an *habitué*, and in which it is as common as enteric fever is among ourselves. On the other hand, there are some districts among us into which typhoid never enters, whilst others have typhoid or typhus as constant residents; in some they

are regarded as unwarranted intruders, and we call the diseases epidemic or endemic, according to the character and duration of their continuance.

It is the study of the laws which regulate these intrusions—the reasons why cholera, or plague, yellow fever, and the like, are endemic in particular places, but only occasionally appear as epidemics in others—which is the business of the sanitarian to investigate; to ascertain the laws which govern these cases, and to put such checks upon their operation as may interfere with their sequences, and prevent their intrusion into a given district.

It cannot be too forcibly impressed upon your attention that it is the sum of the number of contingencies which lead to a condition capable of producing an epidemic. Take away some of the factors of the total, and, necessarily, the conditions vary. Thus, 2 and 3 and 8 and 6 and 1 make up the number 20. Suppose 20 represents some contingency; if you remove any one of the factors the eventuality does not arise. There are some districts into which a particular form of disease is frequently introduced, which, although considered to be infectious, does not spread. Thus, as regards yellow fever, it is constantly taken into certain ports from infected districts, but it never gains a foothold—probably because the temperature of the place is not equal to the requirements of the sum total of the factors. The same rule applies in all other diseases of the zymotic type. We may ask why a case of typhus

which appears in a dark, dirty, ill-ventilated, and overcrowded dwelling is rapidly propagated, whilst a similar case, taken into another house, fails to effect a lodgment. We find that the second house is neither dirty, dark, ill-ventilated, nor overcrowded, and we are justified by experience in assuming that want of fresh air, and the presence of filth and overcrowding, are factors in the production of typhus; and also, if we can take some of them away—those, for instance, upon which typhus depends for its production—it will not have all the integral parts requisite for its development. In consequence, there will be no epidemic of the latter class established in that locality.

On the other hand, if we prevent the introduction of the particular germ of matter upon which typhus depends into a dirty ill-ventilated place, the disease will not arise. These facts have been proved to be scientifically accurate, and they enable us to explain some of the laws which regulate the growth and development of epidemics. They do not, however, explain why such diseases are endemic; why typhus is always present in some places; why small-pox appears now and then, although no particle of small-pox matter can be traced as having been recently introduced; or why enteric fever springs up in unexpected places, apparently "*sua sponte.*" The origin of diseases *sua sponte* has been doubted by some, but Dr. Burdon Sanderson's observations upon the evils which may arise from a continued use of the

products of inflammation in simple peritonitis show most conclusively that mere exudation may become infective, and in the most virulent form possible. If we look to analogy, the cause of these occasional outbreaks will be easily understood. The student of natural history frequently finds similar instances in which animal and vegetable life develop into activity in the most unexpected positions. Insects, vermin, plants, burst forth at odd times, although there has been no recent importation of potent matter or dormant germs. A study of fungology will explain some of these points. The condition of the particular spores called "resting spores" is now fully accepted by fungologists as correct—spores differing in character from those of ordinary fungus fructification, and requiring a different set of conditions for the reproduction of the particular fungus from that spore. This is especially the case with the Peronospora Infestans—that fungus upon which the potato blight depends. Light and air, with dryness and some other conditions, or factors, prevent the ordinary fructification of that particular fungus, or prevent its growth altogether, and the disease is apparently in abeyance in a district; but the resting spores remain undeveloped in the soil. The method of storing potatoes generally adopted preserves them, so that they are ready to spring into activity whenever the conditions upon which their vitality depends come into action in a sufficiently

powerful form to allow of that vitality manifesting itself by renewed growth on an extended scale. The plan at present adopted of storing potatoes in clamps ensures the growth and perpetuation of the fungus, and development of its ordinary fructification. The ordinary spores are destroyed by exposure to light and air, but the resting spores are not so destroyed; they preserve their vitality in a dormant state. These spores become either planted with the seed, or remain in the soil from which some former crop has been extracted, or they may have been conveyed with manure from some dust-bin. Let certain meteorological conditions prevail at particular times; then these resting spores will grow up and fructify, and the crop will be destroyed. Should the required conditions not arise at the proper time, or their progress not be in a proper sequence of order, the potato epidemic would not occur, and the crop will be saved. It may be that the spark, germ, or potent matter capable of setting up the disease is always present, either in the seed itself or in the soil, and only waits for the proper meteorological sequences for its development. There is a strong analogy existing between the action of Peronospora Infestans upon the potato and the disease we call diphtheria, which is striking in various ways. This resemblance shows that the study of the effects of fungi upon vegetable life may be of service in directing us towards a right

solution of the causes and effects of disease in man. I give you my theory for what it is worth, but do not offer it at present as having much scientific value attached to it, because there are possible disturbing causes not yet eliminated. I was led to consider the natural history of the potato disease when it was prevalent some years since. I then published my ideas upon the subject in the *Times* newspaper,* and pointed out at that time that the resting spore had much to do with its propagation and persistency. I had made out in several specimens the existence of the resting spore as a spore different from the ordinary one, but yet capable of developing Peronospora, and had proved to my own satisfaction that it was by the development of that particular spore that the disease was manifested in unexpected places; also, that the resting spore was different in character from that of an ordinary spore—that it might be planted without observation with the seed. Since then, Mr. Worthington Smith has proved that point in a very conclusive manner. He has shown that such spores may be boiled without collapsing, bursting, or even losing their vitality, so that it is possible that they may pass through the alimentary canal of animals or men who consume them even after they have been cooked, and then be conveyed to the soil as manure. It is possible that, like the

* September, 1872.

spores of the common mushroom, they may be rendered more capable of being fertilised by the process. According to Mr. Smith's calculations, a distinctly sexual process is effected by a conjugation of Antheridia and Oogonia, both of which organs are developed in the Mycelium of the fungus; and by their conjugation the perfect Peronospora is produced, thus helping to demolish the theory that fungi are altogether asexual. Mr. Smith is inclined to think that there are two stages of existence for this fungus, and that it is in its aquatic, or that stage which allies fungi in their habitat with algæ, that the resting spores are formed. He found them more plentifully by macerating the leaves of the plant in water for a long time. They require damp places for their production, and are unlike the ordinary spores and zoospores, which are transparent, soon perish, and are quite unable to bear the changes of heat and cold without destruction; the Oospore, or resting spore, is dense in substance, and has an outer covering, which protects it from those influences that are destructive to the ordinary spores. The process I believe to be as follows:—The Oospore, or resting spore, finding a situation congenial to its wants, fructifies in the plant and produces a crop of ordinary spores among the haulms of the potato plant. It may be that a few Oospores only, in consequence of a moderately dry season, are able to develop. If the season is favourable, and the meteorological

conditions sufficient; if there is an absence of direct sunlight, with plenty of warmth and moisture; if there be an excess of carbonic acid in the air, even if not more than twenty or thirty parts in the million, there will still be sufficient for the growth of the plant, and the fungus will perfect its fructification in a few hours. Ordinary spores are then wafted on to the haulms of the plant and develop on the surface, and extend into the plant through the stomata, or breathing pores, of the leaves. The Mycelium permeates through all the tissues of the vegetable, and abstracts to itself that food which the plant requires, by preventing the release of oxygen and by the production of carbonic acid through the agency of the oxygen contained in the juices, which are required for its own nourishment. The plant is actually suffocated and starved, since the introduction of carbonic acid and the exit of oxygen at the stomata are prevented; gangrene follows, as oxygen cannot get out, and carbonic acid cannot get in, whilst that which is there is in the wrong place; it cannot be decomposed; the oxygen which is wanted at the orifices of the stomata, and which is one of the parties to the exchange, is absent at that particular spot. Thus the conditions required for exosmose and endosmose are altered. No proper respiration goes on, and death follows.

The excess of Carbon Dioxide in the air is not great, twenty parts in a million being scarcely

appreciable; yet it does produce its effects, as we know, in many other ways, and as I shall hope to show in a future lecture. This excess may assist to explain why the disease is more likely to appear, and is more frequently developed, in highly cultivated soils; because it is in such fields that oxidising processes are going on most rapidly, as a larger quantity of carbonic acid is present in the interstices of the soil itself. If meteorological conditions are favourable, Carbon Dioxide remains for a few hours among the forest of haulms, and the growth of the fungus is rapidly promoted by it. It is probably for somewhat similar reasons that we find certain diseases more prone to appear in the over-fed and too richly-nourished classes; the gourmand and the drunkard each suffer from the blood being loaded with excess of effete or azotised matter, which prevents healthy development.

Now for the analogy between this disease and diphtheria. Some germ or potent matter finds a suitable soil in the mucous membrane of the throat, fructifies and permeates through the tissues, setting up an inflammatory action in the larynx, and destroys life by suffocation—that is, if death comes on in the early stage. If death results, it is from the want of oxygen. When this suffocating action does not follow, the diseased matter pervades the system, developing, not a continuous Mycelium, but a minute granular matter, similar to Mycoderma or the

Cryptococcus of the yeast plant, but much more minute. These excessively minute granules do not apparently differ from the granular matter which aggregates into fibrine when blood is drawn from the body; they produce that vital change which, if excessive, is incompatible with nerve nourishment —viz., the anæmic stage, that often precedes the suddenly fatal end of a case of diphtheria.

The patient, if he recovers, does so because the pabulum upon which the Cryptococci, or Cacozymes,* feed is not forthcoming; oxygen carried by the blood corpuscles is so diminished that the plant is dwarfed before it can further increase, and it then dies, and is ultimately expelled from the body with some excretion. The red blood corpuscles are altered in diphtheria, and their development is retarded by the disease. I think this arises from their function being interfered with, in consequence of parasitic action. The Cryptococci of the disease interfere with their regular development by keeping in the blood an excess of corpuscles, which show their amæboid character very strongly, and, in consequence, disturb that balance of power which must exist in the blood to enable it to perform its proper duties.

It may be said that there is no proof of the presence of a fungus in diphtheritic exudation, and

* I use this term Cacozyme as truly expressing the nature of the germ, and I apply it to the whole class of disease-producing germs.

certainly a separate existence has not been proven. Nevertheless, the exudation, when separated from the results of inflammation which accompanies it, appeared to me to be very like the sclerotium of ergot. I hope to be able to prove this on some future occasion. It does not differ very much in its action on the tonsil from that of the white cottony patches that accompany the disease which is called dry rot in wood, although it is true that there is no trace of a polyporus—the fungus upon the growth of which dry rot depends —in the structure of diphtheritic exudation. According to Du Barry, the filaments of the Mycelium of Myaxogastres (a species of fungi closely allied to the Peronospora), actually do exhibit a creeping movement and a changeable form like that which is characteristic of amæba. This attribute brings them very near to that which belongs to the white blood corpuscles, and it is possible that such amæboid bodies may, in cases of diphtheria, be mistaken for the white corpuscles themselves. There are many matters connected with the development of minute fungi well worthy of study. As parasites some produce changes of character in plants, which explain many circumstances at present but little understood. If fungi can do so to vegetable life, it is not unreasonable to suppose that animals may be affected by them in a similar manner. Thus the Lychnis Diurna, a unisexual plant, has rudimentary stamens; but, if it is subjected to the influence of Ustilago

(smut), it becomes truly hermaphrodite, the pistil is reduced in size, and stamens are developed.

There is much to be learned by analogy; indeed, a study of natural history is of great use in looking into the causation of epidemics, and it may assist us to explain difficulties. Occasionally an unusual number of the *acherontia atropos*, or death's-head moth, appear. There is a faithful representation of a skull and cross-bones on the back of the thorax of this insect. In former times its advent was regarded with consternation, as being "the messenger of pestilence, the harbinger of woe." The Rev. J. G. Wood, the talented author of "Natural History," tells us how he once saw a congregation in our own country, checked whilst coming out of church. He found them assembled in a wide circle around a poor death's-head moth, which was quietly making its way across the churchyard path. He details how the village blacksmith had the courage to kill it. Mr. Wood keeps the defunct insect as an illustration of the popular ignorance which prevails, and of the destructive nature which such ignorance engenders. We know that the larva which produces the moth requires a continuously high temperature for its development. It may remain in the earth for years without losing its vitality; but, when the proper condition arises, and the requisite factors are at hand, it wakes into life. As these conditions are also necessary for the sequences which give rise to epidemics, popular

ignorance is, to some extent, popular knowledge. The people, however, associate them as cause and effect, and class them as causes when they are merely the common sequences of a concurrence of events. There is a similar point of analogy in the beautiful little fungus called *peziza aurantia.* In captivity it only emits its spores in the direct sunlight; keep it in a badly-lighted place, and, apparently, it is infertile. Supposing that no sunlight appeared for a long time, it is possible that the fungus might be completely lost in a particular district, until new spores were re-introduced.

Gardeners are well acquainted with instances in which diœcious plants remain infertile for years, in consequence of the absence of the male pollen. An accidental waft of breeze or some stray insect brings the required fertilising agent, and the fruit is perfected—much to the surprise of those who did not know the circumstances of the case, and were not aware that the plant was diœcious.

So it is with cholera and other diseases of the same class; if the conditions which lead to their development are absent, they die out and disappear from the country; we may try to prevent the re-introduction of the seeds by the institution of quarantine—that is, the forcible detention of infected persons by entirely separating them from intercourse with their fellow men. The good results which might be supposed to follow from the institution of quarantine appear

to be sufficiently certain to justify its rigorous establishment. The evidence obtained by Mr. Netten Radcliffe with regard to cholera seems to be conclusive on this point. He found that, as a rule, epidemic outbreaks had definite relation to personal traffic. In most, if not in all, of the important outbreaks which he investigated, the arrival in the country of affected persons has been the starting-point of local epidemics; and Mr. Radcliffe states that no extension of the disease had taken place where the arrival of persons from previously infected places was not either proven or rendered probable. His conclusions suggest the value of quarantine as a perfect barrier to the progress of such epidemics as cholera, but other facts which he has also industriously collected offer no great encouragement to the suggestion. Human migration and intercourse between man and man are too complicated and too indefinite to be impeded by any such restrictions. Nothing less than perfect isolation, in a way which would not be possible between nations, could bring about the desired result. The home of cholera is in regions the inhabitants of which would not obey any laws that might be laid down upon the subject, and annihilation would alone be effectual. The disease is diffused by social movements which it is impossible to control or even to examine closely—" those constantly moving streams of religious pilgrims, together with the agents of commercial enterprises, that constitute a large

portion of the national life of those regions whence cholera comes to us;" whilst the habits of the natives also are altogether different, both in manner and effect, to those of European nations.

Mr. Radcliffe says that it is from British territory that this pest comes forth, from time to time, to spread destruction on its path. The first threat of each coming invasion is, that it is doing greater mischief in the area in which it may be said to be always endemic. Under every circumstance it appears certain that at times it will be brought among us by the cupidity, ignorance, or negligence of some one, and that quarantine will not keep it out—at least, such quarantine as we have the power to enforce. Mr. Simon is of opinion that "our safeguards will consist, *not in* the contrivances of the nature of quarantine to maintain from time to time more or less seclusion of nation from nation, but rather such progressive sanitary improvements on both sides as will reduce to a minimum on the one side the conditions which originate the infection, and on the other side the conditions which extend it."

Here, then, is our forte. As sanitary advisers, we may not be able to keep out the germ or potent matter upon which the disease depends; but if we consider this germ to be of a nature similar to that of the common mushroom, and do not allow it to come into contact with the mucous secretion of the horse, a necessary factor in its development—or, to speak more plainly, if we abolish all

those conditions which tend to increase its power of development, those conditions which are always associated with its ravages, such as personal dirt, foul air, impure water, and fœcal abominations of every kind—we shall do much more in the way of preventing disease than by the institution of the most rigorous quarantine which a commercial people are likely to submit to.

The efficacy of preventive measures must depend to a great extent upon the knowledge we possess of the origin, development, and propagation of the particular form of disease against which we are combatting. If we have no satisfactory data upon the subject we must be guided by some theory in our action; otherwise the chance of any successful result following our operations would be infinitesimal indeed.

If we believe in contagion, we adopt some kind of isolation and some form of quarantine, as a matter of course; if we do not believe in contagion, as connected with the disease in question, we take no measures whatever in that direction. There may be differences of opinion upon some points, such as the effect of malaria, cosmic influence, meteorological states, and the effect of underground water as causes of epidemics; but, however we may discuss those points, no one denies that pure air is a necessity, that plenty of pure water is most desirable, that sewage-soaked soil is objectionable as foundations for houses, that stinking houses must be removed, that each

person must have a certain number of cubic feet of air to live in if he expects to keep healthy, and that ordinary excreta must be promptly removed. All these points must be conceded as scientific truths, and hence we have plenty of work to do without traversing debateable ground.

If we determine that a particular form of disease is contagious, isolation of that case should be promoted. This can be effected among the rich and well-to-do without difficulty; but, unless the State provides the means, isolation becomes impossible among the poor. The importation of a single case of typhus, scarlatina, or small-pox is quite enough to infect a whole district, whilst its early isolation would have prevented the epidemic. Sanitary authorities should have at command a place in which isolation can be effectually carried out, otherwise a line of defence is wanting, and the State neglects its duty. Medical advisers should look to this, and urge its adoption upon all Local Authorities, and see also that it is used when occasion requires.

The Society of Medical Officers of Health drew up and recently adopted some resolutions, which have been acted upon by the Managers of the Metropolitan Asylum District Board, respecting provision for the isolation and treatment of epidemic infectious diseases in London. The Society agreed with the Managers that adequate provision for the isolation and treatment of epidemic and contagious

disease in the Metropolis does not exist, and they urged upon the authorities that there should be such provision, and that it should be completely dissevered from any relation with pauperism. If poverty is to be considered in the light of a crime, this is correct. I cannot, however, agree to the principle as a hard and fast rule. The victims of epidemic disease of a certain character, to my mind, may be fairly treated together—if not in the same room, at any rate in the same building, and supervised by the same management. It will be a great boon to the poor themselves that this isolation of class from class should not be a hard and fast line, such as the Society of Medical Officers of Health propose.

In addition to isolation, we should also be able to disinfect. If we admit that there is a germ capable of reproducing its like, or a *materies morbi* of a particular kind, a contagium particle which can be seen and weighed—and this is now accepted as a well-recognised fact in regard to one class of infectious diseases—it is our duty to try and destroy the atom upon which the propagation of the disease depends. From established fact we have to pass to theory, but we may still fairly reason from analogy; we may ask, What do we mean by disinfection, and what is a disinfectant? Intimately bound up with this question is also the more important one as to what constitute the contagia themselves, and how are they propagated.

There are various theories and opinions upon this point, and I can scarcely consider this side of the subject without referring to the substance of those theories. Some hold that they are propagated by albuminoid principles in a state of molecular change; that their multiplication is independent of the presence of living organisms; that albuminoid constituents of a diseased organism can induce a similar state in a healthy body in a manner like to that of Emulsin in its action upon Amygdalin, of diastase upon starch, or of pepsine on albumen; or that the action is similar to the so-called catalytic process. Others hold that the process is biological rather than chemical; that vitality is requisite, without which there can be no multiplication; and that living organisms are associated as an intimate part of the process.

I am inclined to the latter view in regard to the propagation and development of contagia proper. At the same time, I am satisfied that actions similar to those styled catalytic do take place, and are a cause of disease. I believe, however, that they induce disease in individuals, which induction is not followed by a development of fresh foci. It is probable that the *materies morbi* in these cases is ætherial, or volatile, and corresponds with that which sets up hay-asthma, or the rash which is produced by ipecacuanha in some constitutions. The odours of certain plants can produce a kind of catarrh by the effect which

is set up in mucous membrane, but this kind of catarrh, or hay-asthma, is not a disease communicable from patient to patient. The nettle-rash, which follows from the consumption of certain forms of food, is similar in its origin; but it is quite distinct in its mode of propagation to that which arises from the development of fresh foci of disease in the body of a patient, and which constitutes the essence of an infectious disorder, and gives a value to disinfectants. I am bound to say that the ordinary way in which disinfecting materials are commonly employed is useless. Just when serious doubts existed in our minds as to their proper employment, we get, at Mr. Simon's instigation, Dr. Baxter's report upon an experimental study of disinfectants. It is a valuable contribution to our knowledge, and bears out the inferences I had drawn from observation and experience in my own practice. Dr. Baxter defines a disinfectant as "an agent capable of so modifying the contagion of a communicable disease, during its transit from a sick to a healthy individual, as to deprive it of its specific power of infecting the latter."

Dr. Parkes's definition of disinfectants is the sense in which alone they ought to be entertained, viz., "To designate substances which can prevent infectious diseases from spreading by destroying their specific poisons"—taking poison to be synonymous with germ or potent matter—any agent capable of modifying or counteracting the

contagium of infectious disease during transit from diseased to healthy individuals, by means of which it is deprived of its infectious character. There are substances which can only act upon contagious matter after that matter has separated from its parent, and before it has found a new organism in which it may aggregate to itself fresh material for the purpose of reproduction. It has been clearly established, in a way sufficient to make it an accepted scientific fact, that the infective principle of some contagious diseases is certainly particulate; it is neither soluble nor diffusible; it cannot be volatile, although some contagia are heavier than others; it follows, therefore, that disinfection by gaseous matter is surrounded by greater difficulties than other ways. Dr. Baxter says that "ærial disinfection, as commonly practised in the sick room, is either useless or positively objectionable, owing to the false sense of security it produces." That contagia are not volatile was proved by M. Chaveau. He placed infecting liquids derived from cases of small-pox, cattle plague, and sheep-pox in small glass cups; the cups were put into a sand bath at a low temperature, and covered with bell glasses, the outer side of the cups being kept at a lower temperature still; the condensed liquid had lost all power of infecting healthy cases, whilst that which remained in the cup was as virulent as ever. The particles with infective power, being particulate, remained behind; but we must not

forget that, as they are excessively minute, they may be conveyed by gaseous matter, and that a solid, liquid, or a gas may be the vehicle by means of which the contagious particles may be conveyed, and thus it may apparently be volatile.

Dr. Baxter has clearly made out that the character of matter in which the contagium particles are embedded has a material influence upon the effect of the disinfectant. Thus, if it be enveloped in mucus or in some albuminoid matter, it is protected from the influence of re-agents, unless the latter are excessive. This property of albumen is important in its bearing upon the subject of disinfectants, for it encloses each particle in a comparatively hard envelope, capable of resisting the effect of disinfectants for a considerable time. Disinfection may be carried out in either of the three following ways :—

(1) By heat.
(2) Ventilation.
(3) Chemical action by disinfectants.

Heat destroys living organic matter. In most cases 212° Fahr. is sufficient, although shown not to do so in the case of the resting spore of the potato; but 250° will most certainly destroy all morbid matters. I have not, however, been able to develop the resting spore after boiling. A temperature of 225° Fahr. may be equal to the requirements of every theory. If we expose contaminated articles which will not bear the action of boiling water to a dry heat of

250° Fahr., we shall effect our object, provided we apply the heat for a time sufficient to raise the temperature of the article exposed to that point.

Local authorities ought, in every case, to have a proper disinfecting chamber, to which all clothing and bedding that cannot be washed may be at once removed, and the infectious matter destroyed. Powers have been recently given by Parliament to Local Boards to destroy articles which cannot be disinfected, and to recoup the owners for the value of the same. This power is an important one, but it has not, up to the present time, been exercised so freely as it ought to have been. I would, therefore, urge upon you to see that its provisions are put in force, and that the Local Authority actually possesses a place at which disinfection by heat can be carried on. We have used an apparatus manufactured by Frazer Brothers, of Bromley and Bow, for some time with great success. It has been employed in some 1,000 cases, and does its work effectually.* You will understand that I place heat first in the list of disinfecting agents.

The next most powerful agent is ventilation. A current of fresh air, with the ozone which is present in it, or which may be developed by motion or chemical action, destroys all contagious particles if they are acted upon by it long enough. If these

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* A model of the apparatus was exhibited, prepared by Frazer Brothers, and its action was explained to the class.

particles are in all cases particulate, it would appear that currents of air might carry the disease to other places without interfering with their vitality, and so no doubt they do, if it be by means of a damp stream of air, as from a sewer, and especially if to that dampness is added an excess of CO_2; but, if the air be desiccated, and if desiccation be continued long enough, the germs of contagia become destroyed by the power which is possessed by the atmosphere. Were it not so, we should be in imminent and irremovable danger from the presence of a single case of infectious disease.

Ordinary epidemics do not propagate themselves at all times, any more than fruit can be made to grow out of season; but, if the necessary conditions occur for their production, they become generated in a manner similar to that by which figs and pine-apples grow in this country. If the sum of the contingencies requisite for the production, either of fruit or of epidemics, are present, at the same time and place, or in the proper order of sequence, interference with that sequence or order will prevent the fruit from germinating, or the epidemic from developing as such.

I recollect an anecdote told by a lecturer on chemistry at this hospital, when I was attending his lectures, which impressed me at the time most unfavourably as regards disinfectants of the ordinary kind. It was to the effect that

the great merit of disinfectants consisted in the fact that they made such a stink that you were obliged to open the windows to get rid of the smell; and thus, after all, the object was attained by ventilation, and not by disinfection.

The Report for 1875 of the Medical Officer of the Privy Council says that much of the procedure which popularly passes among us as disinfection is but the most futile of ceremonies. "It is," says Mr. Simon, "in relation to individual cases of infectious disease, and to endeavours to secure in detail the immediate neutralisation of the infectious matter which comes from the sick, that chemistry has its chief opportunities of subserving preventive medicine." But he also goes on to say, in more concise words than mine, "that it is to cleanliness, ventilation, and drainage, to the use of pure drinking water, that populations ought to look for safety against nuisance and infection. Artificial disinfectants cannot properly supply the place of those essentials, and in all, except a peculiar class of cases, they are temporary or perfectly useless."

If, however, we do use them—and in one class of cases they ought to be used—we may fairly enquire as to which we may turn for most assistance; and here we find the advantage of Dr. Baxter's experiments.

Taking potassic permanganate, he finds that the portion required to destroy the infective energy of vaccine is relatively large, but that, in such excess

as amounts to half a per cent., it is capable of doing its work. Its effect upon the virus of glanders was more marked, for its virulence was destroyed by 0.005 per cent. Its greatest power was shown in the effect it had upon septic microzymes; a series of eprouvettes were charged with microzymes obtained from Cohn's solution, and varying quantities of disinfectants added. At the end of a week there were no signs of life; the quantity of disinfectant required was relatively small—0.007 per cent.

It was found that chlorine did not destroy vaccine, so long as the lymph retained its alkaline reaction, but if chlorine was supplied, sufficient to acidulate the solution, its infective power was destroyed; this acidity was produced by 0.163 parts of chlorine. Its effect upon dried vaccine was less marked, apparently from the fact that the albuminous envelope partially protected the particle, though the action of the antiseptic dwarfed the action of the lymph.

The virus of infective inflammation required 0.078 per cent. of chlorine to be effectual. The action upon septic mycrozymes corresponded with that produced by potassic permanganate, requiring even less—0.0008 being sufficient.

It was also shown that a high degree of alkalinity did not impair the disinfecting power of chlorine if the latter was free, but that the presence of a certain proportion of albumen interfered with its activity—a difference which

was due, therefore, to the character of the medium.

Carbolic acid exerted no influence in destroying the infective power of vaccine when less than 1 per cent. was used. But 2 per cent. destroyed the power with certainty. The same results also followed when experiments were made with the virus of infective inflammation. The same quantity was also required for the purpose of destroying the virùs of glanders. In some cases 1 per cent. annulled the usual specific effects, but allowed it to produce local and general symptoms of a severe and dangerous character.

The fourth agent used was sulphur dioxide (SO_2). It had a marked superiority over chlorine and potassic permanganate, acting on dried vaccine after the particles had been exposed to its influence for a much shorter period than was the case with chlorine or carbolic acid vapour; but in solution it was not so effective, requiring 3 per cent. to deprive the virus of infective inflammation of its specific powers. Albumen did not protect in the case of sulphurous acid.

In glanders this acid was more efficient than the carbolic, but its action on septic mycrozymes was only decided when it amounted to 0.123 per cent. Dr. Baxter remarks that the time required for all re-agents which he used to act on the mycrozymes did not signify. The re-agent having been thoroughly mixed up with the micrococcus,

the work was done; they seemed to act as poisons upon the organism immediately.

The general conclusion arrived at is that all four agents are endowed with true disinfectant properties in varying degrees. That the effective operation of chlorine and potassic permanganate appears to depend more on the nature of the medium through which the particles of infective matter are distributed, than on the specific character of the particles themselves. That, when these agents are used, there is no security for the effectual fulfilment of the object desired if the agents are acted on by the liquid.

If SO_2 is used, a virulent liquid is not completely disinfected unless it be rendered strongly acid. No virulent liquid is disinfected by less than 2 per cent. of carbolic acid, and that aerial disinfection is a myth, unless the space experimented on has been saturated with the gas in question (SO_2, or chlorine) for not less than an hour. That dry heat is the most efficient, provided that every particle of matter be included in the heated space, and that the length of exposure be greater if the degree of heat be less.

The conclusion which we may fairly draw from our own experience and Dr. Baxter's experiments is, that disinfection as at present practised on a large scale is all but useless. To endeavour to disinfect cartloads of dung by a few ounces of a disinfectant, or to flush a sewer with a few gallons of liquid when the cubical contents

of the sewer may be scores of tons, is a waste of power. It is requisite to deal with the particles of contagion at their fountain head; to act upon their nest eggs freely as they come from the patient; to apply as much as 1 or 2 per cent. of the material used to the material to be acted upon, before it can find a new habitation, or forcing-house, in which it may increase and multiply to an indefinite extent if not so acted upon. It is also necessary to bring the power of heat into play whenever it be possible, and to destroy the contagium particle which may exist in fomites or other lurking places, before it be conveyed to a suitable soil to be propagated elsewhere.

These are the true principles to be acted upon when disinfecting a place:—Destroy the potent particle as soon as possible after it is separated from its parent, and before it is placed in a condition to multiply itself. It is impossible to do this in every case with certainty; infective particles will find their way into sewers in spite of disinfection, and in consequence of this possibility utilisation and disinfection must be in accord—indeed, as far as the former is concerned, it is a convertible term with the latter if it is properly carried out. I shall have to deal with this on a future occasion.

THE ATMOSPHERE.

Sanitary Science should begin at Home—Want of Air and Cleanliness a Cause of Continued Illness—The Atmosphere — Dr. Angus Smith's Work — Ventilation of Sleeping Apartments—Composition of Atmosphere—Carbonic Acid, CO_2—Appearance and Physique of Indoor and Outdoor Workers—Natural Forces Purify the Atmosphere—Phthisis and Strumous Diseases caused by Impure Air—Artisans' Dwellings Act — Improvement in the Death-rate of London—Organic Matter and Disease Germs—Animal and Vegetable Organisms, the Development of—Cause of Epidemics—Average Duration of Life at Present—Age which might be Attained—Individual and Corporate Duties—Free Ventilation—Formulæ for Estimating Velocity of Air, and the Expansion of—Mr. P. Hinckes Bird's Method of Costless Ventilation—Ventilation through Walls—Pettenkofer's Experiments and Calculations—Impervious Walls, Evils of, and Precautions against—Capacity of the Air for Moisture—Sewers, Ventilation of into Houses—Sewer Gas—Impervious Drains—Drain Traps — Want of Sewer Ventilation a Cause of Epidemics—Ozone, its Composition and Properties.

In marking out a course to be followed in these lectures, I started with the statement that the Medical Officer of Health has various duties to perform, many of which I shall be unable to consider. It is my intention on this occasion to deal in detail only with those matters which come under the notice of every practising medical man. I have also started with the proposition that the individual

house is the unit of sanitary work. If the dwelling be properly constructed, whether it be the mortal body itself, or the house it lives in; if its ingesta be of the right kind, and its egesta is properly removed—that is, if perfect cleanliness is insisted on—the best means will be taken to prevent the spread of epidemic and infectious diseases, and even to expel the causes of ordinary every-day complaints.

The sanitary arrangements of the individual house will, therefore, come in for careful attention, premising that it is the shell itself and not the inhabitant with which I have to deal. Every medical man in practice inhabits one such house, and, if he does not know how to provide for his own domestic arrangements, he will not be competent to advise others how to manage theirs. It behoves each member of our profession to look well after his own household arrangements, and not allow them to be contrary to sanitary law, whilst, at the same time, he is advising other people how to get theirs put right.

The want of proper observation upon this point is becoming more manifest to lookers-on, as the general public become wiser. I have heard remarks made by non-professional persons which have been very derogatory to their medical advisers, and to the amount of wisdom and skill which they possessed. This applies not only to the private house of a medical man himself, but to the bedrooms of his patients, and also to those

sanitary arrangements in the patient's house with which the medical adviser must become cognisant, but which he omits to notice and get altered, when they are in a condition that is opposed to the maintenance of health. You will sometimes find patients under medical care who have taken, by the advice of their medical attendant, hogsheads of beer, bushels of pills, and medicine of all kinds, who are unable to define their malady by any particular name, except such terms as debility, want of power, and such like. They are advised to take wine and tonics of different kinds, until they have tried almost every preparation in the pharmacopœia; but the fact that they require fresh air has been entirely ignored. The bed curtains have been drawn around the four-poster; the window curtains and the hangings have been kept close so as to stop every crevice through which fresh air could come. The carpets and other bedroom furniture have absorbed all the ozone that by chance did find its way into the place, and with the natural result that the ordinary impurities which are given out every moment by the inhabitants remained in the room, had a retrograde instead of advancing influence; the patient continued to be poisoned by his own excreta, and also to injure the health of all those who were in attendance. Persons of this class generally dislike to have cleansing operations performed, and, should the doctor be complaisant, the attendants do not often trouble themselves

about it; and so the mischief continues in an ever-increasing ratio.

I am now about to deal with the atmosphere. I include in this term the air of the rooms we live in, as well as that out of doors. I need not detail to you its composition. The lecturer upon chemistry has already entered upon that matter. You know that it is not a chemical compound, but a mixture, varying infinitesimally only in its proper proportions; but, when pure, consisting of certain proportions of oxygen, nitrogen, and carbonic acid, with variable quantities of watery vapour, together with ozone, organic matters of different kinds, both gaseous and suspended, according to the neighbourhood from whence it has been obtained. If you wish to get a good knowledge in detail of the atmosphere, and upon all matters connected with it, I must refer you to Dr. Angus Smith's work on "Air and Rain." This is a book well worthy of careful study, and a close attention to the instructions he has given. There is always great uniformity in the mixture when the air is obtained from some elevated or uncontaminated neighbourhood. But if anyone, after being some time in the fresh air, should enter, at five a.m., into a house which has been closed during the night, and especially an occupied bedroom, he becomes painfully impressed with the fact that the air is not pure. To be called in the early morning to the ward of a general hospital where hygienic considerations are neglected by the

nurses, is not by any means a pleasant incident. A sickening odour is at once perceived, sufficient to fully account for the spread of certain maladies, which are almost endemic in such hospitals; and these maladies cannot be ousted from them for any length of time. The ordinary house is seldom free from some objection or other, whilst nearly every bedroom in this climate might be improved, and the health of the sleepers cared for more than it is. I am far from advising, however, that cold air should be directly admitted into sleeping apartments, whilst occupied as such. Much injury has resulted from such a plan, when it has been injudiciously carried out, as is the case sometimes by persons who sternly resolve to be independent of cold and damp.

However independent we may be in a state of health, when awake, there are few who are able to resist evil from severe cold and excessive moisture when asleep. Judicious attention is, therefore, required as to the time that persons can sleep in the open air with impunity, and any rashness in this direction is to be deprecated.

The usual composition of the air is—

Nitrogen . . .	790.0
Oxygen . . .	209.6
Carbonic Acid (CO_2) .	000.4
	1000.0

These proportions are invariable within a few fractions. The carbonic acid may be only

half that amount, or it may rise to $2\frac{1}{2}$ times that quantity—that is, it may amount to as much as 1 in 1,000 without any serious and immediate observation being drawn to it. The nitrogen is never less than 790, but the oxygen may be positively decreased in amount. There are variable quantities of vapour, which is greatly influenced by the neighbourhood of a water supply—the moisture may be almost *nil* in a dry sandy desert, and approach to a maximum in certain temperatures near to the surface of the sea. There is occasionally a deal of sulphurous acid and some sulphites, as in the atmosphere of London, Manchester, and other large towns. Generally there is ozone, and also minute traces of organic matter, such as ammonia, nitric acid, nitrous acid, and those suspended matters which are always found in certain situations. We also find epithelial scales, spores of fungi, and other germs, which develop into bacteria, desmids, diatoms, and rotiferous animalcules, as well as dusty particles of inorganic matter; but I must again refer those who wish for very specific and detailed information upon all these points to Dr. Angus Smith's book on "Air and Rain." This work should be mastered by all who intend to make observations upon the atmosphere, and especially by those who intend to qualify as Medical Officers of Health.

Resuming our review of the constituents of the air, we will now consider carbonic acid (CO_2) more in detail. This gas is found in excess in large towns

and in densely-peopled places, rising in some situations to as much as 1 per cent. It influences some forms of fungous growth very much, by promoting the development of certain spores, which will not grow unless in the presence of an acid solution, or with excess of carbonic acid in the air.

It is probable that dry rot and other fungous growths may be promoted by its presence, for dry rot only takes place in those situations in which there is no ozone, in which carbonic acid is in excess, and in which ventilation, in its proper sense, is almost impossible. This fact explains why dry rot is sure to appear in any building in which the architect has neglected to provide for proper ventilation among the timbers. CO_2 increases in consequence of the natural oxidising processes which are always going on. The spores of fungi, which are present in the juices of new woody matter, develop as soon as they have a chance, and by their own growth increase the tendency to evil, for they also increase the amount of CO_2 in the air of the place; and so dry rot extends in a wonderfully rapid manner when it has once had a fair start.

Pettenkofer has made out that CO_2 exists in excess in the soil of cities like Munich, and that, the deeper the position in the earth from whence the air was taken, the larger the percentage of carbonic acid became. Professor Nicholls, of Massachusetts Institute, has also made out very clearly that the amount of CO_2 is always greatest in the neigh-

bourhood of decaying matter, and decreases in amount towards the surface of the ground. The maximum was observed to be present in July and August; it decreases in winter. Professor Nicholls did not find that the neighbourhood of well-constructed sewers produced any effect, but in the soil near badly-constructed sewers (as in Munich) it was always in excess. The opposite opinion has, however, been held, apparently on insufficient data. I believe it will be found, on further enquiry, that the increase is only observed in the vicinity of those sewers which do not fulfil the object for which they have been constructed, but which are liable to retain deposit and allow the decomposition of their contents, and also of percolation into the surrounding earth; then, naturally, as the sewage soaked away, CO_2 would be formed in excess in the saturated soil.

The rapid distribution of gaseous matter which naturally follows from the law of diffusion of gases, which is inversely as the square root of the density, tends to keep the composition of the air in an average state. This is caused by the repulsive action which each gaseous molecule exerts against its neighbours, and which tends to bring about a constant equilibrium in the ordinary constitution of the air, provided we let natural forces have full sway—that is, if we allow of that ventilation which Nature is ready to establish if we permit her to do it in her own way.

No one can consider the personal appearance

of the adult inmates of our London shops, or the designers and workers in an ordinary factory, without being struck with the complete physical difference which exists in their blood as compared with that of an adult agriculturist, or of one who always lives in the fresh air—even with that of a London cab-driver. I say adults advisedly, for it frequently happens that the children of agriculturists are as pale-faced and as delicate-looking as are town dwellers, or of any that can be found in our London courts and alleys, because the children of agriculturists very frequently occupy damp, close, ill-ventilated, and overcrowded dwellings; they have their sanitary arrangements cared for even less than the denizens of our city courts and alleys. A person who lives in the open air, or inhabits a well-ventilated and carefully-appointed house on the slope of a hill, has a very different appearance from the ordinary town dweller, or the factory lad. The one is florid-looking, with hard, well-developed muscles, and great strength; the other is pale-faced, has flaccid muscles, and is comparatively weak as regards physical power. The one has abundance of red blood in his capillaries; the other has a much larger proportion of white corpuscles, which appear to indicate an arrested development, as if the corpuscles had not progressed in their growth in the right direction, and had been unable to assimilate the proper kind of nourishment, in a manner similar to that

which we observe in the vegetable kingdom when light is obstructed. The one is generally able to undergo great fatigue and exposure without risk; the other is exhausted and rendered incapable by a little extra exertion, and he takes cold if he accidentally gets his feet wet or is exposed to an unexpected shower of rain. These differences are produced by two sets of circumstances; one being a deficiency of oxygen in the air respired, a deficiency which is infinitesimal in itself, but which, if multiplied by the number of inspirations required in the course of a day, makes a material difference in the quantity of oxygen inhaled; the other consists of the presence in the inhaled air of an excess of CO_2 and some organic matters which are really extraneous, and not proper constituents of the air. If these extraneous matters are not properly and rapidly removed, they assist in keeping a deficiency of oxygen, by a constant diminution through taking the minute proportions required for the oxidisation and removal of the patient's excreta. If, therefore, the air of a given place is naturally pure, it is easily rendered impure by a crowd of human beings, or any other animals, or by any action which tends to diminish oxygen, and adds to the unnatural constituents of the atmosphere. The oxidising power of the air is diminished, and matters are added which depress health. If, therefore, the *débris* which is the natural result of the act of living be not consumed or provided

for as Nature intended, there will be quantities of inflammable and deleterious matter scattered about, either in the air of the room, which is capable of acting upon other people; or in the blood of the manufacturer himself; and this matter is able to set up mischief in those organs to which it naturally gravitates. Occupation is thus provided for the medical practitioner, in ways which would not have arisen if pure air had been forthcoming for the habitual respiration of the patient. Perhaps the quantity of oxygen which is missing is not more than half a grain, or at most one grain, in 1,000—that is, one-tenth part per cent. It may not even have passed from the third place in decimals. Dr. Smith gives 209.780 as the average amount of oxygen which was yielded in many analyses of London air out of doors; in some cases the amount would rise to 209.800. In various places he examined the air from middens and cesspools, and found the amount so low as 206.500; there was a loss of 3,300 in a million parts. "Nature," says Dr. Smith, "never seems, under ordinary circumstances, to offer us air with a loss of even 1,000 in a million." Comparing healthy places with unhealthy, the difference is about 200 in the million; this amount may indicate a similar variation of vital principle in the air, the effects of which we may understand by analogy. Half a degree in temperature may make a complete difference between solidity and fluidity in the case of water, or a single grain may turn the scale of a balance in a

case in which 10,000 grains are being weighed; and under certain circumstances the infinitesimal quantity of oxygen which is missing, when multiplied by the number of inspirations in a given time, becomes sufficient to make a serious difference to the person inhaling it.

There are two other points still more important to be considered in this question, one of which is that, whenever oxygen is deficient, it is replaced by carbonic acid. It may be that the presence of CO_2 in excess is more deleterious than the deficiency of oxygen. The quantity naturally present is not more than one-fifth of CO_2 to half a grain in 1,000 of air, its natural quantity being 0.04 per cent.; serious evil will arise sooner or later if that quantity be exceeded. Some doubt may be felt as to whether the evil is produced by the CO_2, or its accompaniments, the latter of which constitute the second point. There is an augmentation of the average of carbonic acid in the summer, as compared with the winter, in the ratio of 77 to 100. The mean quantity in January in 100,000 parts is 4.23, but in the month of August it is 5.68. There is even a manifest difference in parts per million in calm weather, as compared with windy seasons. It is washed out of the air by rain, and is, curiously enough, found in larger quantities in the upper regions.

The air above the clouds naturally contains the larger quantity. I cannot avoid coming to the conclusion that epidemics are occasionally promoted

by germs which have been developed in the upper regions of the air, where they have been floating about for some time; and that some of the influenza outbreaks that have preceded the cholera advents have been connected with this meteorological fact. The rise of CO_2 into the higher regions, going on for a long time in a calm air, without the purifying influences of rain, may give increased life to the minute organisms which are always found, even in the most elevated regions of the atmosphere. It is necessary to remember that the change as regards CO_2 does not pass from the third place in decimals.

The necessity for keeping the air of a given place pure requires an easy method of finding out when the impurity exceeds the standard quantity of four to six grains in 10,000. There is a simple plan for ascertaining the increase of impurity. We diffuse carbonic acid so rapidly that a $10\frac{1}{2}$ oz. bottle of the air shall not give any precipitate when shaken up with half an ounce of pure lime water. Great care has to be taken in charging the bottle with the air proposed to be examined, for, if it is breathed into in any way by the operator, the experiment will not give reliable results. If we want to know with great certainty whether there is an excess of carbonic acid—that is, whether the air really contains more than 0.04 per cent.—a bottle holding 7.06 oz. must be used. If it is filled with the air to be examined, and then shaken up with half an ounce of baryta

water, it will give no precipitate unless there is more than 0.04 per cent. of the gas. If the quantity of gas has risen to 0.08, it will give a precipitate with two ounces of the water; and thus we have a fair and easy method of getting at something like a quantitative analysis of air as regards the principal impurity, and we may fairly conclude that, if the CO_2 is not in excess, other contaminating agents are not present to any great extent.

Dr. Smith says we must attend to the change in the value to the third place in the air of theatres, workhouses, badly-ventilated rooms, and even that of middens; and, for scientific purposes, even to the fourth, which only represents one part in a million. The effects of poisons on health are not in proportion to the effects on the sensations; it is so with CO_2. The effect upon sensation is, indeed, *nil;* but there are other things that accompany the production of CO_2 which are more injurious than the latter, and assist still further to diminish the purifying power of the air by using up all the ozone which may be present in the air. Wherever you have excess of CO_2 from the action of animal life, there you have also an excess of other *débris*, such as the organic matters which pass off from the respiratory organs; septic matters given off from pulmonary membrane, very manifest in some diseases to the sense of smell; impure matters in the insensible perspiration; ammoniacal compounds

from retrocedent decompositions—all of which are the most injurious of such impurities.

Contaminations may also have been caused by chemical changes independently of animal life. There are the ordinary products of combustion to be dealt with, and those imperfectly destroyed matters which contribute to form smoke. All of these must be removed, and, if pollution has arisen from the decomposition or fermentation of organic bodies, there are the thousand and one products which can be manufactured in Nature's laboratory, all of which tend to resolve themselves into a few ultimate elements; but by so doing still further diminish the available supply of oxygen in the air.

All the matters which are produced in such abundance, wherever human beings congregate, tend each in its own peculiar way to deteriorate the air we breathe, and to lay the foundation for other and greater changes. Measures must be taken to obviate all these effects, and to restore the proper equilibrium in the constituents of the air; to get rid of the unnatural elements, and bring back those which are missing. The measures to be adopted separate themselves into two classes—the personal, or those which individuals must do for themselves; and the municipal, or those which must be done by the Local Authority. Time will fail me to do more than point out directions on these points. The mere aggregation of human beings on a given

spot deteriorates the air, by organic changes which the human machine produces, as well as by those actions which result from decomposition of the egesta, which rapidly arises when they have left the body.

The circumstances under which these contaminations take place arise generally at the time when the natural forces which Providence has established to purify the air cannot have full sway. These impurities are increased by negligence in not providing for the proper purification of air, when depreciation of health necessarily follows. The natural forces are wind, rain, and that law which regulates the diffusion of gases, together with the influence of vegetation in removing carbonic acid (and other *débris*), and the restoration of pure oxygen in its place.

Some calculations made by Dr. Angus Smith show that these forces are fully equal to deal with CO_2. He shows that 15,000 tons of carbonic acid are discharged yearly into the air of Manchester by the immense combustion of coal which is always going on there. He adds to this the amount of carbon given out by each person as 7.55 ounces per day, which equals 15.6 cubic feet of CO_2. Then he adds the amount of CO_2 always present in the air; this he calculates at 0.06 per cent: taking the cubical quantity of air above the city for 300 feet in height, and reckoning the average daily speed of air at 12 miles per hour, Dr. Smith then shows from

these figures that, notwithstanding the excessive quantity of CO_2 produced, the ordinary quantity of 0.0600 only rises to 0.0693, and does not reach 0.07 per cent. in the open air, even in Manchester. That increase makes a difference of 93 parts in a million, which is a serious change in the quality of respired air, amounting to 293 parts in the million more than ought to be present. Such quantities, apparently small, become serious when presented to the pulmonary membrane throughout the year. We get full evidence of its effects in the death-rates of the country, 293 parts in a million establishing a serious impediment to the action of exosmose. The blood is not revivified so perfectly as would be otherwise, and *débris*, which should have been removed, remains behind in the human economy, ready at the first opportunity to spring up into another kind of life, and produce disease in those organs which have to deal with the extraneous material.

The Thirty-fifth Report of the Registrar-General informs us that the most fatal class of diseases to which the inhabitants of the British Islands are subject is phthisis; that 108 deaths out of every 1,000 are caused by it. To these may be added a large number of other diseases which are registered under the names of atrophy, debility, marasmus, and the like, with which may be placed the list of so-called strumous diseases, bringing up the total to more than one-fourth of the number of deaths as actually caused by this class of disease. The

evidence of all those whose opinion is worth considering tends to show that these diseases are especially the result of respiring impure air—air which has either been breathed by other persons or by the same person over and over again, or depreciated by the removal of some of its oxygen by ordinary combustion, without its having been exposed to the purifying influences of fresh oxygen and active motion in the open air. A large portion of other diseases have their mortality increased by the presence of impurity in the air supplied to the sick. Here, then, is a field for sanitary officers which is almost unbounded. It is only by educating ourselves first, and the people afterwards, in the right principles as regards purity of the atmosphere, that we can hope to prevent the consequences of impurity. We were shown, not long ago, how the poor manage to live, or rather exist, in London, by the evidence elicited at an enquiry promoted by the Metropolitan Board of Works under the powers of the Artisans' Dwellings Act. This Act is to be put in force in Whitechapel, and the proceedings refer to one of the schemes which have been brought forward in London for the removal of the nuisances that arise from overcrowding and carelessness on the part of the owners of house property. The district is inhabited by the lowest class of poor. Such nuisances as arise from overcrowding can only be cured in those densely populated districts by the entire removal of the houses in question. The

Artisans' Dwellings Act of 1875 gives power to Local Authorities to deal with such places. In one part of Whitechapel, an area of 6½ acres is, or was until a recent period, occupied by 444 houses, having 4,350 inhabitants. The death-rate has been over 48 per 1,000, as against 24, which is the normal death-rate of other parts of the same parish.

I showed, in my last lecture, that overcrowding need not necessarily be attended by excessive mortality if provisions are made to obviate its effects;* but such provisions cannot be made in the houses in question. The evidence produced at the enquiry I have mentioned went to show that, wherever cholera, fever, small-pox, and other zymotic diseases were epidemic, they produced their ravages in those overcrowded districts with greater virulence than elsewhere. People who lived in the neighbourhood referred to, were sick, disabled, and demoralised, because their dwellings were unfit for human beings to live in. The area under notice, with its 644 persons to the acre, had also an average of 10 living in each house.

It is in circumstances like these that all the decencies of life are violated, and, as a natural consequence, the human stock degenerates. The

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* Our leading statesmen are fully aware of this, as will be seen from the extract of a speech made by the Earl of Beaconsfield on the 23rd June, 1877, at the opening of one of the Victoria Dwellings Association new buildings; *see* Appendix.

death-rate of 48 per 1,000 represents but a small portion of the mischief. The most thoughtful and most intelligent among the residents, as they grow up, leave the place; but they carry with them the germs of disease in their constitutions, which assists to lower the vital power of their surroundings. Mr. Simon calculates, as the results of his experience, six cases of illness to every death that occurs from zymotic diseases. This will give some idea of the amount of sickness, poverty, and misery which is entailed upon the poor, and those who are compelled to reside in such neighbourhoods. We may be thoroughly in earnest in grappling with these matters, but it will take many generations before we shall be able to eradicate the evils that are daily arising, even if we had the power to prevent all future evil from similar causes.

Times have greatly changed since the days of Queen Elizabeth, and very much for the better, since we find that in her days the average death-rate was more than 42 per 1,000 in London. There were, at that time, in England, only 15 houses and 82 people to the square mile. There are now 713 houses and 4,061 people to the square mile. London has also altered very much since the beginning of the seventeenth century :—

In 1681—96	the population was	530,000,	death-rate	42.
,, 1746—55	,,	655,000	,,	35.
,, 1846—55	,,	2,362,000	,,	25.
,, 1876	,,	3,100,000	,,	24.

It will be seen that there has been a manifest improvement in the health of London within the last two hundred years, but it has not yet reached the level that it will do, if the ordinary laws which regulate health are attended to in a proper manner.

The presence in air of other than the natural constituents may be easily shown by a few experiments. Organic impurities do not diffuse so rapidly as the CO_2. The suspended matters may be arrested by an arrangement of microscopic slides, and the arrested material can be then examined. The slides should be inserted in a cylinder through which a current of air is made to pass. The collection may be obtained by an arrangement of glass slides, fixed in cylinders in ice, and a current of air passed through them; the microscopic slides should be fixed in their transverse diameter, upon one side of which the air is made to impinge, the surface of the slide being coated with glycerine. By this arrangement, pus cells and epithelial cells have been obtained from the air of an hospital ward. Epithelial cells may be easily discovered, and the spores of fungi and other vegetable cells are frequently found if the watery vapour which abounds in the air in a crowded assembly is collected and condensed on a slide; microscopic cells are found to be abundant, and, if these are placed in favourable circumstances, they will develop into bacteria, vibrios, mycelium,

zoospores, monads, and bacteroid bodies. The organic nature of the material arrested is shown by the fact that it is precipitated by nitrate of silver, it blackens platinum, and ammonia can be obtained from it; whilst it has the fetid smell which is indicative of nitrogenous matter.

Dr. Cunningham has shown how many different animal forms may arise in succession in the same specimen of rain water which had been collected at a great height above the ground, and kept for several days free from the admission of any fresh external air. He shows that such water, sooner or later, always produces mycelium, spores, monads, bacteria, and zoospores, but not any of the higher form of infusoria; it is certain that the germs, or potent matter, upon which their development depended had been wafted from the earth into the upper regions. He found, however, nothing but bacteria and the spores of aspergillus in the air of sewers. He thinks that the circomonads and amobœ found in specimens of pure rain water are zoospores, developed from the mycelial filaments arising from common atmospheric spores. Bacteria also appear to arise from a kind of mycelium developed from atmospheric spores. The dust collected in any close, ill-ventilated room, as from the top of a bookcase or from the string course in the ward of a large hospital, if added to putrescible liquids which

have been treated so that all contained spores have been destroyed, develop fungi and bacteria, although recognisable specimens of such bodies cannot be found in the dust itself; whilst the dry vegetable cells, which are constantly found in such situations, always produce desmids and other vegetable organisms. It would appear as if the air always contained germs ready to develop into animal or vegetable life, according to the character of the material which forms the pabulum in which they are enabled to grow. Some germs, like those which give rise to Protococcus pluvialis, may be dried and yet retain their vitality for years, whilst others undoubtedly become soon resolved into their original elements by desiccation. It would appear as if each germ had two kinds of existence, one which enables it to defy atmospheric changes in a limited degree—the other is evanescent, and requires moisture for its continuous life. It appears certain that germs of living matter do circulate freely in air, ready to develop into one or other of the kingdoms of Nature, according to the manure bed in which they settle. If that bed has in its constitution something which has had an animal origin, then the production is animal; but that, if the manure bed is vegetable only, then the product is vegetable—the germ, or potent matter, taking either course according to circumstances. This view of the matter will be received with doubt by many, and is altogether opposed to

the ideas of a powerful school. I am of opinion, nevertheless, that renewed research will show that it is the correct one.

Do these germs promote epidemics? Can their presence in air be connected with the progress of epidemic disease? Countless germs are present in air at all times. Some of them produce changes which were thought to have been produced by oxygen. Some, bacteria for instance, require oxygen in the medium in which they develop, and they will rapidly die if all oxygen is removed from it. Other species, like some vibrios, develop when there is no free oxygen, and they evolve ammonia. Some grow only in an acetic fermentation; others, again, only show themselves in the butyric acid series. According to Pasteur, a variety of changes in fluids are brought about by different kinds of germs. The torula forms produce alcoholic fermentation, if the temperature is kept up; mycoderma, an allied condition of torula, give rise to the acetic fermentation, but the temperature has to be kept down; vibrios flourish in the butyric fermentation, and some species, as those to which the sarcina ventriculi probably belong, set up the lactic fermentation; whilst other forms can only be multiplied in an alkaline fluid, as the presence of acid stays their production, and prevents the decomposition of those hydrogen compounds upon which the development of ammonia depends. All these points are matters of great importance in connection with the spread of

epidemic diseases. I am bound to confess that I believe in the idea that germs do promote the spread of epidemics.

Returning to the subject more immediately under consideration, let us examine the condition of any common lodging-house at five a.m., and the sense of smell tells us that the air is impure. It must be felt before it can be described; it is impossible for conditions such as produce these palpable effects to continue without depreciating the health of those who are compelled to live in such places, even after taking into consideration the small amount of depreciation in the air, to which I have previously referred. I have already spoken of the air of our bed-rooms, and the accumulated evils of re-breathing even a slightly vitiated air. The air of our theatres, concert-rooms, ball-rooms, churches, dining and drawing-rooms, is generally much worse than it ought to be; too often, indeed, the air of those places shows a gross neglect of the laws of health. When we go into the homes of our working classes, or the elementary schools occupied by the children of the poor, there is seldom any doubt about the effluvia being decidedly unpleasant, to say the least of it, although an analysis shows the very small loss of only 90 parts in a million.

The sense of smell also tells us plainly that the larger portion of the people of this land live in an atmosphere deprived of its full proportion of

oxygen, and adulterated besides with nasty impurities, generally the exhalations of our own production—the result of decomposition of excrementitious matters. These are too often kept in close proximity to our living-rooms, instead of being hurried away to the soil, the natural laboratory which Nature has provided for their effectual deodorisation, disinfection, as well as utilisation. The depreciation that arises from our own neglect is so great and general, and the results therefrom are so disastrous, that it is wonderful we have so long apathetically submitted to them. From these causes the duration of life in this country does not extend beyond 41 years. This is shown by Dr. Farr to be the average age at death in England—an average which, it is true, is higher than it is in any other country in the world, but which, after all, is very far short of that hundred years which is promised as the regular length to which life will extend when the laws of health and morality shall be obeyed, and our neighbour considered as well as ourselves.

The Prophet Isaiah says (lxv. 20)—" There shall be no more thence an infant of days, nor an old man that hath not filled his days; for the child shall die an hundred years old."

This promise will be realised when sanitary laws as well as all other laws are obeyed, and the obligation of people one towards another always taken into account.

The remedies against the shorter life which we now possess, and the method by which we may add length of days to those who are in the way to die young, are two-fold. They are, first, those which follow from municipal or concerted action or inaction; and, secondly, those which it is the duty of the individual householder to do for himself. The line of separation between these two classes cannot be well defined. In the majority of instances, if the householder does not do his duty, the Local or Municipal Authority may, in some cases, compel him.

For example, if we assume that a depreciation of the purity of the air is caused by overcrowding and deficient sanitary conveniences, we conclude that the constant re-breathing of an air which has already been deprived of its oxidising power must have the effect of shortening life and establishing a nuisance. The landlord to whom such description of house-property belongs, failing his duty, incurs a grave responsibility, in default of which he may be called upon by the Local Authority, as the custodians of public health, to reduce the number of inhabitants within safer limits, and also to provide better ventilation; that is, supposing the place in question be a common lodging-house. If the evils alluded to occur in a private house, the law does not authorise any interference, unless a palpable nuisance arises therefrom; and this is an extremely difficult point to prove.

The first great principle to be followed is to change the air of the place by providing for free ventilation. "Free as air" is a favourite adage. Out of doors there is generally no difficulty in ventilating the neighbourhood of the densest population, since the vertical height of air is so great, and its horizontal movement so rapid. It is different, however, if the horizontal movement be interfered with in any way. In ordinary circumstances, depreciation from a crowd of human beings out of doors is unappreciable, but a mass of people could be suffocated in a well, even if the top were uncovered. If a number of persons are closely packed in a large building, or even in a tent, the contained air becomes stifling, unless measures are taken to change it. This is very palpable when it becomes nearly saturated with moisture from the lungs and skin. This saturation soon takes place unless the air is constantly changed. The exhaled moisture, with its attendant carbonic acid and organic matters which accompany it, must be removed as rapidly as they are formed, if we would keep the air pure. It has been proved that air rushes into a vacuum with a velocity equal to that which a heavy body acquires in falling from a height of five miles, viz., 1,340 feet per second; but if, instead of passing into an empty space, it rushes into a chamber where there is less pressure than outside, its velocity will then be represented by the differ-

ence between the pressure outside and that within. This amount of variation may be arrived at in an approximate manner by considering the difference of temperature between the air outside and inside. Air dilates 1 in 491 of its volume for every degree—that is, if 491 cubic feet of air are raised one degree in temperature they become 492 feet. This expansion is practically equal for every degree, so far as we are called upon to calculate.

Dr. Parkes gives the following formula for estimating the velocity:—"The height from the aperture at which air enters to that from which it escapes, multiplied by the difference of temperature outside and in, and divided by 491." There is a decrease of velocity from friction, which is in proportion to the length of the tube, and is inversely as the diameter. Right angles greatly increase the friction, and should be avoided, if possible, in all ventilating places. I shall allude to this, at a future time, more fully.

It is not my intention to detail all the means in use, or which have been suggested for the purpose of ventilating large rooms and dwelling-houses. They are legion. I shall keep to general principles only, premising that it is stagnation which is really dangerous; that air in motion is absolutely necessary for safety. The point, therefore, to be aimed at is, that the motion of the air shall not be such as amounts to a draught. Very few requisites are really necessary to ensure the proper ventilation of a dwelling-house, although, when

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we come to figures, the quantity of fresh air which must be introduced to keep the atmosphere pure appears to be enormous. We are told by good authorities that, if 1,000 cubic feet of air is allowed to each person, it must be changed three times within an hour in order to keep the carbonic acid down to its normal standard of 0.04 per cent. If we allow the quantity to rise to 0.06 per cent., then 1,500 cubic feet per hour must be introduced. To effect this without producing an objectionable draught is a difficult problem. The Sheringham valves, Moore's window ventilators, Galton's ventilating stoves, Potts' ventilating cornices, Watson's syphons, ordinary sun-burners, and what are called Tobin's principles—these are all valuable in their respective ways, and in certain situations, but all are liable to go wrong. Dr. Ball, of Spalding, has also a plan in connection with the fire-place, which is very good if managed by persons who understand it. Most patents act well in theory, but in practice they are liable to be disarranged by officious nurses, ignorant attendants, or wilful patients, who insist upon altering the principle upon which their correct action depends, when, of course, the result is not that which was intended. The principle to be kept in view is, either to bring warmed air into the room, or to introduce cold air in such a way that it shall distribute itself among the hot air near to the ceiling, and then descend in a warmer state; we may let in fresh air, and allow the impure air to

get out as it can ; or we may pass out the impure air, and allow fresh to get in by the easiest channel. These methods are all good in theory, except the last, which is bad both in theory and practice, because, if fresh air is not provided for, that admitted will come from impure sources. All are inefficient in public rooms and closely-packed meetings. Perhaps Watson's syphon is the best, in principle ; but it is liable to be put aside by persons who will insist upon having the windows open when they ought to be closed, or doors closed when they should be left open, and then the system is interfered with, and breaks down.

In cold weather, I love to see a good fire, with a large open chimney, which compels a constant change of air in the room, by the draught it creates, independently of the quantity of air consumed by the fire; I am not scientific enough to wish to see it changed for invisible warmth. In hot days I like to see open windows, sufficiently large to get a rapid change from the movements of the air, which is assisted by the difference of the outside temperature as compared with that within, viz., 1 in 491 for each degree Fahr. The fashionable form of fire-place, in which all exit of air is denied, except through the fire, is a serious disadvantage. It shuts out one of the principal ways by which the air of a room in olden times used to be changed. Windows should be made to open top and bottom, extending as nearly as possible to

the entire height of the room; and if to these, in towns like London, are applied the plan which an old student of St. Thomas's, Peter Hinckes Bird,* invented, and which he has styled the "costless ventilation system," there will be little need of anything else in an ordinary living-room (which directly communicates with the external air) to ensure a perfect ventilation, free from draught. If the custom of consuming gas with an ordinary burner prevails, then additional ventilation must be provided. Gas should never be used for household illumination without an outlet being provided for the products of combustion. The arrangements of the room must be such that there be inlets for fresh air from without, as well as outlets for the discharge of freshly formed impurities.

These exits and entrances must be regulated according to the number of the inhabitants and the character of the retaining walls before a pure air can be at all times provided. Pettenkofer has shown us that sandstone, limestone, brick, and mortar each transmit air through their interstices in very varying proportions. He has explained very clearly why it is that damp houses are more unwholesome than dry ones; why ventilation is imperfect in the one as compared with the other, all other things being equal. He proved by experiment that in one

* See Appendix for a full description of this method.

hour 1,000 cubic feet of air passed through 21 square feet of a free wall of sandstone. In that time the same quantity of air passed through

15	square feet of	quarried sandstone.
12	,, ,,	brick.
7	,, ,,	mud.

Pettenkofer does not mention the thickness of the wall, but, as it was the free wall of a room of his own in which this spontaneous ventilation equalled seven cubic feet of air per hour for each square yard of wall, we must conclude that a great deal of spontaneous ventilation does take place through the walls of ordinary dwelling-houses, provided they are not made of impervious materials. Iron-houses, glass-houses, and houses the walls of which are covered by silicious compounds, which entirely prohibit the passage of air in this spontaneous manner, are much more unhealthy, for an obvious reason, than those old-fashioned porous walls which allow a considerable amount of spontaneous ventilation to take place through their substances. When the walls are of considerable thickness, as is the case in all old brick-houses, the air would have its temperature raised in its passage through them; and such houses are safer and more comfortable to live in than the modern thin-walled brick villa.

This porous property is to be borne in mind when providing walls for hospitals and other buildings in which it is suggested that non-porous

materials should be used. They are perfectly non-absorbent, it is true, but they also entirely prohibit the chance of spontaneous ventilation, and prevent that change of air which would otherwise take place in the corners and dark places of the building. They allow the air to stagnate to a serious extent; unless such stagnation is counteracted, this may lead to the continuous presence of evil where it is not looked for. The inlets for fresh air, when impervious walls are constructed, must be far greater than when the walls allow of the passage of seven cubic feet of air per hour per square yard, as was the case with Pettenkofer's room. It follows from this fact that, as the superficies of an impermeable wall diminishes the amount of air per person, according as it increases in capacity, small rooms, which accommodate fewer people, are safer than large rooms for a larger number—that is, if the cubical contents per person remain the same. The cubical space which is required for each individual in a dwelling is regulated by the ventilation. It is usual to fix a limit, within which it is not safe to pass, but in reality the quantity of air that enters into a room within a given time is of more importance than the size of the room; but it is necessary to have some guide as to the space which must be provided. In the army there are regulations in force which provide 600 cubic feet for each man. This is doubled in hospitals, viz., 1,200 feet. The Local Government Board allows

300 feet for every healthy person in the dormitories of the workhouses, and from 850 to 1,200 feet for every sick person. In common lodging-houses 300 feet for each person are required. The London School Board at first allowed 130 cubic feet for each scholar in the general school-room. This has now been reduced to 80 feet—a quantity too small, unless very free ventilation is provided. There are, however, many points to be taken into consideration besides cubical space, such as the furniture, character of warming apparatus, and ventilation. Experience shows that the largest room, without ventilation, is liable to become dangerous to the occupants, although the cubic space is far beyond the regulation allowance.

The capacity of air for moisture is another question which has to be considered. This property is one which exerts a great influence upon the ventilation. It depends upon three conditions, viz. :—

(1) The tension of vapour, which varies at different temperatures.
(2) The quantity of water already in the air.
(3) The velocity of the air itself.

A cubic foot of air at 50° Fahr. can take up four grains of water in the shape of vapour. If it is already three parts saturated—that is, if it contains 75 per cent. of water—which is the ordinary condition in which we find the air of a room under such conditions as I have described, a

cubic foot of air can only take up one more grain of water. It would require a long time to diminish moisture, and dry a damp room by simple ventilation alone. A room containing 6,000 cubic feet of air could only get rid of a few grains of water per hour, for increase of saturation beyond 0.75 is not rapid. But if we warm the room, and raise its temperature by 18 or 20 degrees, we increase the tension of vapour—that is, the capacity of the air for taking up extra water—from four to seven grains per cubic foot, so that each cubic foot of fresh air entering the room is capable of taking up seven or eight grains instead of four; which means that each cubic foot of air admitted into a room at 50° Fahr., and whilst there, has its temperature raised to 70°, abstracts four grains of moisture, and thus helps to get rid of 20 times the quantity of water than would have been the case if we had left the room unheated.

Upon these principles we are able materially to promote ventilation ; a rise of temperature within the room is followed by a change of air, and any difference of temperature leads to motion. These are the only means by which we can properly ventilate an ordinary dwelling-house. A room containing many people naturally has its temperature raised by the crowd of people themselves; but the congregation load the air with moisture, and if that is not changed it very soon becomes insupportable. To establish a current, therefore, which shall take out the excess of

moisture is the first point we have to accomplish. That current will also remove the excess of carbonic acid, and the ordinary exudations of the living body. This is the problem we have to solve. It must not be done by the production of a perceptible draught, as will be the case if we establish a greater velocity than five feet per second. If we ascertain the transverse section of inlets, and also of outlets, and if we multiply their surface by the velocity of the air, this will give the cubic quantity of the air which flows through these channels in a certain time. Again, if we know the required quantity of air, and divide it by the transverse section of the channels, we get at the required velocity of air in the inlets and outlets. If the velocity is greater than three feet per second, which is about two miles an hour, we must enlarge the channels.

It has been found that in ordinary times, when there is no perceptible wind, the air still moves at the rate of three feet per second. We may treble this velocity and raise it to six miles an hour without mischief, but, beyond that point, draught is established, and evil results may follow.

Ordinary dwelling-houses need not be artificially ventilated. The natural means of attaining this object—such as by the difference of temperature, with the sequence which belongs to the increased tension of vapour at the higher temperature inside the house, and the consequent motion of the air from without which

naturally follows, dry porous walls, and the temporary assistance which is obtained from open windows and proper fire-places—ought to be sufficient to keep the quantity of carbonic acid and other deteriorating matters to a minimum, if overcrowding be avoided. Add to these a proper attention to cleanliness, so that the matters capable of fermentation and decomposition are not allowed to set up a manufactory on the premises, and no obstacle is permitted to interfere with or arrest the laws of motion and diffusion, and all will be right.

On the other hand, if the inlets for fresh air from the outside are closed, or arranged that only an infinitesimal quantity is admitted, in order that a perceptible draught may be avoided, then air will find its way in through all sorts of improper channels. The most frequent and most dangerous inlet for air into a house is from the sewers, or from underground sources which are already loaded with CO_2 in excess. It is obvious that air drawn from such supplies must have all its oxidising power abstracted by the organic matter with which it has been already in contact.

In alluding to sewers as one of the sources which supply vitiated air to badly-arranged houses, when no provision has been made for proper ventilation, I am only stating that which is a well-established fact. If a house is so arranged that no provision whatever has been made to provide inlets for fresh air, it is morally

certain that the house drains are also badly arranged, and that proper provision has not been made for their ventilation; and, as a necessary consequence, they ventilate themselves into the house direct.

I shall leave the subject of sewers in general for consideration in the lecture upon sewerage, but I will introduce here the principle which is the right one to follow in providing for the efficient ventilation of sewers themselves.

This subject is one which every year grows into greater importance as it becomes more fully understood. I may refer to it with some degree of confidence, since I was instrumental in inducing a Local Authority to adopt the correct principles of ventilation in a considerable area, some time before such ventilation was thought to be at all requisite by Sanitary Authorities in general. In the year 1854 this necessity was very forcibly brought to my notice in the district in which I reside, and I had very soon a practical proof of the necessity for, as well as the benefit arising from, a system of sewer ventilation. I have repeatedly brought the subject before the profession in the medical journals, and under the notice of the public in the *Times* and other newspapers in various ways. Many years since I propounded a theory as to the ventilation required. This theory is now generally recognised as embodying the correct principle, and, in consequence, is meeting everywhere with that acceptance which was strongly denied

to it in the first instance, the theory being *motion* as opposed to *stagnation*.

It was not until the introduction of water-closets into houses, and their connection with main sewers by means of impervious earthenware pipes, that sewer air was sufficiently isolated in such a manner that it could be positively identified, and the evil results arising therefrom rendered palpable and distinct. Previously to the introduction of water-closets and the abolition of cesspools, the sanitary evils of the day were so great that the mischief produced by sewer gas could not be separately assessed. The large drains which were made of porous brick materials actually saved people from consequences which could not be foreseen, and the results of which could not be guarded against, and, as a matter of fact, were not provided for. The pervious brick walls of large drains gave place to impervious pipe sewers, and, as the sewage rushed down, air rushed up to supply the vacuum produced. This air would be comparatively innocuous, except that it had been deprived of its ozone. If the sewers had been constructed in the way that they were originally designed—viz., that they should flush clean, and not be the elongated cesspools that they were intended to supersede—the principle, in theory, would be right; but in practice, unfortunately, it does not answer. Engineers and architects delegate the authority of attending to the construction and levels of house drains and other

similar matters to subordinates, who delegate to foremen; they, in turn, relegate to bricklayers' labourers the duty of laying that part of the work which is even more important than forming the foundations of the houses. As a necessary consequence, the work is badly done in the majority of instances, and deposits do take place in the house drains. The deposit may be small in amount, but, small as it may be, it is sufficient to produce mischief. It is detained in a place from which fresh air is excluded; butyric or other acid fermentation takes place, and this leads to the development of large quantities of sewer gases, which have to find a way out of their prison-house as best they can, and the easiest and most general way in which they escape is by the house nearest to the point at which the gases are produced. Mechanical arrangements, called traps, are usually placed to keep them in; but, as there is a great difference of temperature inside the house, compared with the external air, the gases are able more easily to pass through the traps which are inside the house than through those which are outside. There is an exhausting action going on within the house which absolutely requires air from without, whilst most of the apertures communicating between the exterior and the interior of the house are zealously closed; consequently, air finds its way into the house most easily from the sewer. The pressure of sewer gas on the sewer side of the trap is so great that it

easily overcomes the resistance of the trap itself, as there is only the thinnest layer of water (or perhaps none at all) between the warm air of the house and that of the drain for the sewer gas to pass through, and so it gets into the house.

Traps in sewers promote another evil. Even if the inward pressure is not sufficient to overcome the trap they produce stagnation in the sewers themselves, and with stagnation of sewer air you have an atmosphere in which nitrogen and carbonic acid are in excess, and ozone is absent; consequently, those matters upon which the production of epidemics sometimes seems to depend for their propagation have a favourable opportunity of reproducing themselves.

Ventilation, which is necessary in sewers, is precisely the same as it is in houses—we require to get rid of stagnation and allow the natural forces which exist in air to have full play; to bring into action the laws regarding the diffusion of gases, the tension of vapour, and the changes which arise from the alteration of temperature; to make exits for air which has passed through the sewer, as well as to provide entrances for fresh air; to construct the exits in such a manner that the air from the sewer shall not enter into houses and stagnate there. The whole theory and practice of ventilation, therefore, consists of motion as opposed to stagnation, and it is the same in sewers as it is in all other places—circulation of air must be rapid and incessant, like to that

of the circulation of the blood, or of the sap in trees. The impediments to its transit must be of such a character as can be easily overcome. "Free as air" must not be absolute in sewers, for freedom must consist in air always going in one direction. The influence of sewer air in setting up disease, in promoting and spreading epidemics, and keeping disease among us in the endemic form, need not now be insisted on; you may take from me that it is an undoubted scientific fact. I shall allude to it again in dealing with the causation of such diseases; but, accepting it now as a fact, I propound a theory which, if always carried into practice, would prevent the consequence of sewer air from being felt, by opposing its production or, if produced, preventing the concentration of mischief. Theory with practice, applied to a large district, has been found successful; for, as ventilation was carried out in the particular district to which I have alluded, disease disappeared, although, when the principle was first applied, it was general in that locality. This was especially observed in that particular district in 1866. Years passed on; a popular prejudice arose against the so-called stink-pipes. They smelt sometimes, because it happened that the sewers in the district had been inefficiently laid, through the foolish action of the authority under whose care they had been constructed and extended, and the deposit they gave rise to produced stink. They became, in fact, sewers of deposit; numbers

of them were tampered with by ignorant plumbers, who defied the Local Authority with impunity. That authority forgot the effect of the faint smell of sewer air, and allowed stinks to concentrate in the sewers, in a manner similar to that which caused the epidemic of 1866; and in 1875 another widespread epidemic of typhoid arose in the same district, and was traced in a great measure to the same cause—want of sewer ventilation, which became more manifest when any interference with the water supply took place, the principal agents of the epidemic being want of sewer ventilation and intermittent water supply.*

When typhoid or other infective excreta find their way into sewers without having been previously disinfected, they meet with small masses of deposit, and are arrested. The ordinary butyric acid fermentation arises; a large quantity of gas is evolved, and carries with it the germs of mischief, capable, when deposited in suitable soil, of setting up the disease wherever it has an opportunity of multiplying. The germs are carried by the current of air, which the production of the gas itself assists to establish, to some of the highest points in the sewer, and escape by the easiest channel they can find, which is generally into some house having untrapped openings; these are frequently in close contact with the water supply. Pure water absorbs these gases most rapidly, and with it the albuminoid ammonia, that conveys

* *Brit. Med. Journal*, Vol. ii., 1876.

the contagium particle upon which the production of epidemic disease depends.

To obviate this, several things are required. First, sewers must not be sewers of deposit; but if they are, and it is most difficult to prevent deposits occasionally, then provision must be made for the exit of the gases which are produced into the open air, and not on any account to allow them to come into close communication with water supply. To effect this object, arrangements must be made for a free exit, and with those arrangements there must be entrances for fresh air as well as exits, inlets as well as outlets. I press this on your attention as of great importance. These entrances must admit fresh air into the sewers in abundant quantity; for, in the presence of a free current of air, that stagnation upon which the first commencement of acid fermentations depends cannot take place, and the formation of contagium particles is much impeded. If, however, from the nature of circumstances, it is found that such particles are produced, then it follows that a proper circulation of fresh air in the sewer will ensure that immediate dilution which will prevent evil, since dilution with motion means destruction of the specific power of the contagium particle. Ventilation carries it away into the outer air as soon as it is formed, and there it soon meets with the atmospheric condition which will change its chemical constitution; and with that change there will be a loss of vital power, and consequent

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inability to develop in the direction which is required to set up epidemic disease. This is the theory of ventilation. The principles which are to effect this object I will deal with when speaking of sewers.

I have frequently mentioned the word ozone, and spoken of it as an ordinary constituent of the atmosphere. The chemical lecturer will have informed you as to its nature—viz., that it is an allotropic form of oxygen. You well know that chemists are accustomed to consider the minute indivisible particles of gas as atoms, which, by their aggregation, form molecules. The molecules have an equal size under the same temperature and pressure, and a given volume always contains the same number.

The formula for oxygen is now considered to be O_2; in my student days it was O. The molecule of ozone contains the atoms of O_3, and its formation means the condensation of oxygen into two-thirds its former volume. If this view is correct, and it is agreed to by most Savants, ozone consists of condensed oxygen, and is simply allotropic; it is in a form in which it parts most readily with the third atom of oxygen. Ozone and oxygen are therefore mutually convertible the one into the other, without the formation of any other body. There is a close alliance between ozone and chlorine, but in what way is not yet made out. The great power and the usefulness of ozone is as an oxidising agent. It purifies water

and air by removing organic matters, destroying putrid exhalations in a most wonderful manner. It differs from oxygen in possessing a powerful odour and taste, in decolorising blue litmus, corroding india-rubber, oxidising silver, decomposing iodide of potassium, transforming ammonia into a nitrite and then nitrate, combining immediately with phosphuretted hydrogen, with the emission of light, decomposing hydrochloric acid, and liberating chlorine; it is an energetic bleacher, and is destroyed at high temperatures. All these properties prove ozone to be the most sanitary agent that exists in Nature.

Does the atmosphere at all times contain this powerful sanitary assistant? It appears that some processes of Nature are constantly producing it; whilst other agencies are constantly at work to keep it down, especially the acts of man. Almost all kinds of meteorological changes tend to increase the quantity of ozone; it is produced by slow oxidisation at ordinary temperatures, and indeed by all actions which tend to set atoms of oxygen free. It is produced in large quantities on the surface of the sea, and also when oxygen is liberated by vegetable growth. The decomposition of carbonic acid releases the oxygen partially in the form of O_3. Wherever there is a large expanse of sea, and wherever there is vegetation actively going on, there is an ozone manufactory which is available for use by the Medical Officer of Health. It maintains the salubrity of the atmo-

sphere by destroying its impurities, and is sacrificed by the act of doing so.

We cannot transfer the sea to all parts of our land, but we can promote healthy vegetation. It follows, therefore, that it is a duty incumbent upon the medical man to do all he can to promote the proper cultivation of our soil, and by so doing transform barren and unhealthy tracts of country into fruitful and healthy land. This is effected by conveying to the soil all decaying organic matter, by means of which the carbon therein contained shall not be given out, either as carbonic acid or any other noxious gases, by its decomposition, but by transforming them instead into vegetable tissues; and by returning a large part of the contained oxygen to the air in a form which enables it to assist in purifying the atmosphere, instead of promoting its deterioration.

Ozone is found in the open country, at sea, on the mountain side, and in all healthy localities where there is a current of air sufficiently rapid to change the atmosphere as the ozone is removed. It is seldom found in the centre of large populations, unless in a high wind, and then the quantity is very minute, even at its greatest. It is destroyed by the products of combustion. It is constantly deficient in densely peopled cities, although I am inclined to think that it is seldom entirely absent out of doors, but that our tests are not sufficiently delicate to detect its presence. I

must refer you to Dr. Cornelius Fox's work on ozone for all particulars regarding this wonderful re-agent, premising that its presence is detected more easily in the higher regions of the air; and even the difference of a few feet from the ground will change the character of the observation in the same locality. This is easily accounted for by the ozone in the lower strata of the air being influenced by the changes which are always going on at the surface of the earth. It is seldom, if ever, detected in the wards of a large hospital, or even in a room inhabited by a sick person.

Dr. Richardson has suggested its manufacture as a means of cure in the wards of our hospitals.

It has been declared that the evaporation of water, under the influence of light and air—ventilation, in fact—promotes the formation of ozone; it has been found more frequently near to rivers and lakes supplied by running streams than at places removed from such sources. Like everything else, it does harm in excess, and its over-stimulating power has to be thought of as well as its absence regretted. It destroys mould, and it may be that its presence in excess is one of the reasons why places constantly exposed to sea breezes are not favourable to some forms of minute vegetable life. The character of vegetation has also an influence on its production, for the coniferæ, or fir tribe of trees, seem to favour its production, and the strong smelling flowers which are used as perfumes assist to produce it.

There is reason, therefore, in the use of perfumes, and even the incense of the votaries of the church in the Middle Ages was probably not without its use, as at those times epidemics were frequent. Some far-sighted monk had no doubt noted the beneficial result of such things in improving health. Like many other agencies, such as fasting and fish diet, they had their uses, which led the wise observers of Nature to formulate their use into dogmas, in order to ensure the due observance of the instruction and thus obtain its benefit.

WATER SUPPLY.

Water—Supply of—Duty of Sanitary Authorities Regarding—Examination of—Animalculæ—Qualities of Water—Qualitative Tests—Sources of Supply—Springs, Wells, Rain, Rivers, Lakes—Gases in Solution—Hard Water—Salts and Mineral Matter in Solution and Suspension—Clarke's Process—Chlorides as Evidence of Sewage Pollution—Nitrates and Nitrites—Organic Matters Reduced by Oxidation—Rules for Guidance—Local Authorities to Provide a Supply—Water Companies and Municipal Authorities—Distribution of Water—Constant and Intermittent Supply—Sanitary Axioms—Water and Gas Service-pipes—Lead and Iron Water-pipes—Average Requirements per Head of Population—Albuminoid Matters Develop into Bacteria and other Forms of Life—Filtration a Doubtful Process—Intakes—Air and Motion tend to Purify Contaminated Water—Rain Water—The Wandle Valley and Chalk Districts as a Source of Supply.

AFTER the consideration of air, the next subject that demands our attention, is water; the requirements of the public as to its quality, and its quantity; the duty of the Sanitary Authority with regard to its supply; the evils which follow from its contamination; and the method to be adopted in its distribution.

The qualities of a good water are both of a positive and negative kind. They may be considered under three headings—(1) the Physical, (2) Microscopical, and (3) Chemical. It would be well

to pause before using it, if the proper qualities are absent. Water should be without colour and quite transparent. This point is easily proved by examining it in a glass cylinder 2 feet long and 1 inch in diameter, filling it with the water to be examined, and looking through it when placed erect upon a sheet of white paper, and compare as to colour with a pure standard. You must recollect, however, that I am not about to show you the method of making a minute chemical examination. You will already have learnt the principal details of that important process, and I intend only to bring back to your recollection such points as bear directly upon our subject, and which you can put in operation out of the laboratory. If it is found that the water departs from a pure standard, and you wish to know why this cause of impurity arises, the lessons you have already learnt in the laboratory will instruct you in the course you must pursue in order to get at the details of the case, and to form a just conclusion as to the quality and quantity of the impurity.

The qualities of good water are also that it is without colour, taste, or smell; you find this latter out by shaking the water in a wide-mouthed flask. If it is then found to be without smell, it should be heated, and a few grains of caustic potash added to it. Should there be much organic impurity in the water, the smell will discover its presence. If it is a very hard water

you will have also evidence of that fact, for there will be a precipitate of carbonate of lime. Water should be neutral, also, in its action on test paper. If any of the necessary conditions as to colour, taste, or smell are absent, you must enquire the reason why before you recommend that water for use. For this purpose you should take a clear white glass flask (a Florence oil flask does very well); have it thoroughly cleaned, and then filled perfectly full of the water to be examined; shake it up, and hold it between yourself and a bright light. If foreign matters are in suspension, they will be immediately perceived, and in some cases their character can at once be determined, especially if living organisms exist in it; but it will be best, before deciding the nature of the foreign bodies, to make a microscopic examination, which will give you material and decided information. At the same time, you must understand that such an examination of water is not always of positive service, because the most injurious matters are not to be detected by the microscope; an analysis, however, would not be complete if it is not fully carried out, while for a superficial investigation the microscope is invaluable. The water to be examined should be placed in a tall jar or bottle of transparent glass for 24 hours, carefully covered, so as to exclude any foreign bodies. The supernatant water should then be removed by a syphon, and the sediment examined on a slide, the deposit being rapidly

transferred to it by a pipette. A good water will not show any sediment, whilst bad water will generally give evidence of contamination, in the shape of earthy or mineral matters which have been held in suspension ; cottony fibres, all kinds of *débris*, both animal and vegetable, are occasionally found—bacteria, ciliated infusoria, paramecia, amœba, confervæ, diatoms, algæ, indeed all kinds of animalcular life. You may also find distinct evidence of sewage contamination in the presence of epithelial scales and muscular tissue. The presence of animalculæ is not to be regarded as a positive proof that the water is unfit for drinking purposes ; sometimes it may be taken in the contrary sense, because the tendency of ciliated infusoria and entomostracan crustaceans is to remove organic matters from the water and to stay the progress of putrefaction. Indeed, life of that character is generally destroyed when putrefactive changes are actually established. The major portion of animalcular life then departs, and it is wrong to condemn water because a few are present, unless other conditions indicative of impurity exist. Animalculæ are often found in rain water, the germ which has produced the creatures having been washed out of the air. Erenbergh endeavoured to show that they are natural scavengers, assisting in the purification of water, just as plants do, by producing oxygen, and fixing carbon and phosphorus. They are antagonistic to the fungi which absorb oxygen and give

out CO_2. You will often see figured in different publications microscopical figures of horrid creatures which we are said to swallow. They are, however, innocent of evil, and perform for the water that which the many kinds of birds and other living things do for us in our fields—they pick up dangerous substances and transfer them into food for other living things. If it were not for animalcular life in our water supplies we should more often suffer from insanitary evils than we do now. Diatoms, desmids, and vegetable matter in small quantities need not condemn water. Still, their excessive presence should lead you to be suspicious of that in which they appear, because their presence indicates the presence of material on which they can live and multiply, and that material is organic and injurious. But there is no deduction to be drawn from their occasional and scanty appearance.

Organic matter may be qualitatively determined by boiling a few grains of trichloride of gold with several ounces of the water. If nitrogenous matter is present, the gold is reduced, and falls as a violet or dark powder. Another useful test, which gives still more important information, is potassium permanganate. Two grains should be dissolved in 10½ ounces of distilled water. Take a portion of the water to be examined, acidulate it with a few drops of hydrochloric acid, and add the test until a faint pink tinge is perceptible. Every ten drops of the permanganate solution provides for

1-1000th of a grain of oxygen. The amount of oxidisable matter in the water can be calculated sufficiently to enable you to condemn the water if organic matter is in excess. Organic matter, sooner or later, decomposes this test. If the colour is rapidly discharged, you may condemn the water at once, for rapid discharge of colour is due to sewage contamination. These enquiries enable you to determine that a given water is not pure; but for correct judgment in a doubtful water, and for the purpose of giving legal evidence as to its impurity, you must follow out a regular analysis in the qualitative and quantitative manner.

The presence of injurious metals is indicated by the sulphuretted hydrogen test. A small indication should condemn a water, and you should not allow such a source of water to be used for supply if any suspicion of lead, arsenic, or barium presents itself.

All potable waters are either hard or soft; soft waters being those which are obtained directly from the clouds without having come into contact with soluble matters of the earth. This water, being collected as it falls, or falling upon primary rocks, does not become saturated with soluble earths; hard waters, on the contrary, are those which have fallen upon and soaked into the earth, and made their appearance at some other spot, charged with salts and organic matters which have been dissolved in their course through superficial strata. Their nature is indicated by

the character of the contained foreign matter. For the purpose of comparison, we enumerate potable waters as—

(1) Rain water.
(2) Lakes in primary geological formation.
(3) Rivers from the same districts.
(4) Other rivers.
(5) Springs issuing from the ground. And,
(6) Wells.

Rain water will contain the least, and water from wells in lime, cretaceous, and recent formations the most inorganic matter in solution. Rain water may contain a minute quantity of chloride of sodium when collected near to the sea, and nitrates occur in the water of thunderstorms, but otherwise it is generally free from inorganic matter; whilst other waters show increased quantities, according to the sources from whence they have been obtained, until, as in the case of water from cretaceous formations, we may have 30 or 35 grains of lime salts in solution without being obliged to condemn it as an unwholesome water. Water which is from a granitic or clay slate, and some other formations, like that supplied to Glasgow from Loch Katrine, has but 2.3 grains of solids to the gallon. Some waters from a sandstone formation show one or two grains only. The water supplied to St. Thomas's Hospital has about 18 grains to the gallon, principally lime salts; that supplied to the town of Croydon, which is a chalk water, 24 grains to the gallon; that supplied by

the Kent Company has 26½ grains; Scarborough water, which is another chalk water, has 28½ grains. As a contrast to this, I may mention that sea water has 2,688 grains of solids in each gallon, mainly chlorides. These quantities are approximate.

Besides the solids, water contains gaseous matters of various kinds. The solubility of gases in water is generally taken as one of the proofs that the atmosphere is a mixture, and not a chemical compound, for we find the quantity of oxygen in solution is in much larger proportion than that which exists in air itself; and as in air, so in water, the proportions are not regular. The gases in solution may amount to as much as 7 or 8 cubic inches in the gallon. It is the presence of these gases which adds to the freshness, briskness, and palatability of drinking water; whilst water which has no air in it is flat, insipid, and somewhat mawkish to the taste. The relative proportions in which they are usually found is, nitrogen 65.1, and oxygen 34.9. The oxygen amounts to more than half the quantity of nitrogen which is found, instead of being scarcely more than one-fourth, as is the case in the atmospheric mixture. I am, of course, referring to a pure water. We find that the oxygen may be, in a great measure, removed by certain oxidising processes which are continually going on in water which contains organic matter in solution or suspension; and, in that case, large

quantities of carbonic acid may have taken the place of oxygen. The difference in the atmosphere of water, so to speak, as compared with air, is even more marked as regards CO_2; for river water, containing much decomposing organic matter, has given out on analysis CO_2, 30.3; nitrogen, 15.0; oxygen 7.4—four times the amount of CO_2 as compared with oxygen. That is the proportion of gases contained in a litre of Thames water taken at Kingston.

According to the same analyst, Dr. Miller, a litre of water at Woolwich gave off 63.0 cubic centimètres in the following proportion :—

Carbonic Acid (CO_2)... ...	48.3
Nitrogen	14.5
Oxygen	0.25

The oxygen being in a great measure replaced by the CO_2, we need not go farther to enquire why fish could not be found in the Thames. This state of things is now being altered, and the condition of the water at Woolwich is better than it used to be at Kingston. We may hope the time is not far distant when CO_2 may be all but banished from the water at Woolwich, and the Thames restored to its original *state of purity*.

A litre of water deprived of all gases, and freely shaken up with large volumes of air at 60°, will absorb 17.95 cubic centimètres of air, those being the proportions I have previously mentioned—viz., nitrogen 65.1, oxygen 34.9, in

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100 volumes. The ordinary amount of CO_2 in pure water is very small. If water is boiled, all the absorbed gases are driven off, and it tastes flat. The effect of boiling upon a hard water is shown by its becoming cloudy, and when this cloudiness is excessive it is not so good for dietetic purposes, unless it has been previously boiled, or treated in some way which will act in a similar manner. The carbonate of lime, upon which hardness depends, is rendered manifest by heat, which decomposes the salt. It existed in solution as a bi-carbonate; this is changed by heat into a carbonate; an equivalent of CO_2 is driven off, and the mono-carbonate of lime subsides, and, as it falls, it frequently shows crystals of arragonite, which form hard plates, furring up hot-water pipes, steam boilers, and tea-kettles, in a way which, to say the least of it, is very disagreeable, and may be very dangerous. But hard waters are the most wholesome, and in all cases to be preferred for dietetic purposes. The power of water to retain only small quantities of lime, the almost universal existence of lime in water, and the limitation of the quantity, are facts not without significance in a point of health, and in providing a water supply I should always give the preference to water which was moderately hard.

Excess of lime is thrown down by boiling, and the salt much reduced in quantity. All things, therefore, which are treated with boiling water are prepared with that water, reduced by

the boiling process to the quality of a moderately soft water. The same process of boiling also removes a large proportion of other objectionable matters. Boiling reduces the bi-carbonate of lime to a mono-carbonate. That is the reason why it is necessary to observe that water boils well before it is used for tea-making, and also why it is much easier to wash with water which has been boiled than with a cold hard water. The same object is attained by artificial means in a very easy manner, by adding an equivalent of calcic hydrate to the water itself. This process is commonly called Clark's process. It renders the water more pure and better fitted for the purposes which Nature designed it; that is, if a pure chalk water is acted upon by the calcic hydrate, and provided that the caustic lime is not added in excess. The softening process tends to remove by coagulation any albuminoid matters which exist in the water. These impurities are carried down by the lime as it precipitates, and in this manner the process assists to purify the water. The result is precisely similar when water is boiled, except that the extra equivalent of CO_2 is arrested by the calcic hydrate, and is not lost.

Water which has been purified by Clark's process is not so palatable to the taste as an ordinary hard water, for there is less atmospheric air than in a water which has not been limed; but the atmospheric air may be restored to it by agitation,

and then its qualities as a grateful beverage are regained.

By Clark's process all colouring matter is also removed from the water, especially if that colouring matter is derived from a vegetable source.

We speak of water as containing so many degrees of hardness. The term is used as indicating that so many grains of lime per gallon are in solution. The process for determining the degree of hardness is simple. Pure distilled water dissolves soap, whilst hard water curdles it. The lime in the water unites with the fatty acids in the soap, and forms an insoluble salt. The whole of the lime or magnesia in the water must be made to combine with the fatty acids of the soap before any lather can be formed. The measure of the amount of soap which is then acted upon gives a measure of the sum of lime in the water. The soap test, therefore, is arranged so that a given number of cubic centimètres of a solution of soap are made to represent so many grains of lime. So much soap destroyed, before a lather is produced, represents so many grains of lime in the water. Thus, if it should happen that 16 centimètres are required to produce a lather which must persist for five minutes, it is said that the water has 16 degrees of hardness, and that there are 16 grains of lime per gallon in the water. The calculation of a grain for a degree is not perfectly correct, but it is near enough for ordinary purposes. For all particulars regarding the manipu-

lations which are required to render you master of detail in this matter, I must refer you to works of analytical chemistry, especially to Wanklyn's "Water Analysis," which is a simple and easy method, and also to Dr. Frankland's papers on the same subject.

After boiling the water for some time, and straining off the precipitate, it is generally found that a certain number of degrees of hardness remain which cannot be removed by longer boiling. This is called the permanent hardness; a large degree indicates a bad water for ordinary dietetic purposes. It shows the presence of sulphates of lime and magnesia in the water, and there may be also excess of chlorides of the same earth, as well as common salt. Such water should be used cautiously, as it is not of a satisfactory kind for a general water supply. If taken freely, it may give rise to diarrhœa and irritation of mucous membrane, disturbances of digestion, and functional derangements of the liver; whilst it is said to produce goître, as well as other glandular disturbances. It is right, therefore, for you to look at the permanent hardness of a given water with suspicion, when that hardness is higher than 3 or 4 degrees.

The total amount of solids should not in any water exceed 35 to 36 grains per gallon; when the permanent hardness exceeds 8 grains per gallon, it is not good water; if 10 grains, it is decidedly indifferent; whilst 12 grains should

prohibit it altogether as a potable water. I may call to your recollection that 1 grain per gallon represents (as you know) 1 in 70,000, or 1,428 per 100,000.

Permanent hardness is increased by the presence of chlorides. The chlorides require careful consideration in assessing the value of a potable water, with regard to health. They are not of very much consequence in themselves in the minute quantities in which they ordinarily exist, but they may be of serious consequence in connection with their accompaniments. If a number of analyses of a particular water give at all times the same result as to the quantity of chlorine present, it may fairly be assumed that the chlorine has a mineral origin; but, if it rises and falls, and its rise is attended by increase of the quantity of ammonia present, there cannot be much doubt as to its source being from sewage—especially if it varies considerably from the quantity contained in the general water supply of the district, and, moreover, was not at some former analysis found to be a normal constituent of the water in question. If the water is nearly devoid of chlorine, it cannot have been charged with sewage; still, large quantities of chloride of sodium may exist in the form of common salt, which has been derived from marine formations, without it necessarily following that the water is polluted with sewage. The chalk waters generally show about 1.2 grains per gallon, whilst polluted wells and subsoil

springs will occasionally show 5 to 10 grains per gallon, with a corresponding rise in ammoniacal compounds. Bala Lake has 0.7, probably washed out of the air; the Thames, at Eton, 1.2; Croydon water, 1.2. The connection between sewage and chlorine has been worked out by Wanklyn; and, as an approximate process, its estimation may be used in emergencies, bearing in mind that the absence of chlorine does not determine that a given water is pure, any more than its presence proves impurity. There may be vegetable contaminations which are to be avoided in drinking water, and which may not provide chlorine. Against this form of pollution the absence of chlorine is no guarantee. It is always indicated by the presence of organic carbon; and, when this exceeds a certain percentage, it stamps the water as bad. The quantity of organic carbon in a given water is arrived at by determining the quantity of the other residues which are left on evaporation, burning out the combustible matters, and calculating for the nitrates, nitrites, and other matters not carbon. The residue is, with certain provisoes, calculated as the organic carbon present in the water; it ought not to exceed one grain in the gallon.

The next point of importance is the quantity of nitrates and nitrites in a given specimen. Like chlorine, they are not of much moment in themselves, and in small quantities are not injurious; indeed, they give a sparkling character and a

freshness to the water which is agreeable to the palate, but they are evidences of the oxidisation of organic matters. Dr. Frankland has considered them also as evidences of so-called previous sewage contamination, although they do not indicate that the previous contamination is recent; it might have been that which existed a thousand years ago. Nitrogenous matters decay, and turn into nitrates by the oxidisation of the nitrogen they contain, but we must bear in mind that all rain water contains a small amount of nitric acid; that most spring waters contain a considerable quantity of nitrates, amounting often to 2 or 3 grains per gallon, especially when obtained from a country in which agriculture is carried out on arable land. The South Essex waters have 2.7, and some of the purest springs from the deep chalk waters have 1.1. The presence of abundance of nitrates does not necessarily imply a defilement by sewage, neither does a deficiency show its absence, for nitrates are found to the amount of 0.205 grains per gallon in the water supplied to the people of Croydon, as pure water from a deep spring; but there is none in the same water when it passes as sewage on to the farm. When, however, the nitrates are considerable in quantity, it is wise to take care and enquire whether the previous sewage contamination may not be liable to be increased. The soil through which the nitrates are passing or being manufactured may be about to become surcharged,

and unable to continue the work of oxidising the water which filters through it; for if all oxygen is removed from the soil, and no fresh supply afforded, the purification does not take place, and the albuminoid matters in the sewage pass through unaltered, as will be shown when we deal with the subject of filtration.

It has been urged that, as water contains nitrates, and nitrates must necessarily have been at some time or other contaminated by sewage, such water should never be drank. Eminent engineers, taking advantage of the admission of chemists and physiologists that single germs of organic albuminoid matter cannot be detected by analysis when mixed with immense volumes of pure water, have urged upon communities that waters proved pure by analysis are not to be depended upon, and should not be used, because of the possibility that previous sewage contamination may become absolute and present before it is discovered. It has been argued that underground waters are unsafe, upon the idea that, if typhoid fever is due to the presence of living germs, such germs, finding their way into a subterranean stream, continue to live, to increase, and multiply in that underground current, and spread evil to the consumers of the water so contaminated. The case published by Dr. Frankland, of typhoid spread by underground water in a Swiss valley, is quoted as conclusive proof on this point. (It is fair to state, however, that the conclusions

which Dr. Frankland drew from that incident have been rightly questioned.) The advocates of water supply from sources " above suspicion," as they term it—viz., from the clouds, and mountains, or uninhabitable regions—are advocating an impossibility as far as the mass of people are concerned, and are forgetful of the power of the Divine Author of the universe to provide against such a contingency. If rain water carried down carbonic acid in excess, and kept it in solution, instead of allowing it to enter into combination with earthy salts, and at the same time did not carry down and absorb the large amount of oxygen which it actually does, viz., 34.9 per cent ; if nitrates and nitrites did not exist in the water, such a condition would probably be present, and this does occur in stagnant soils which are devoid of drainage, and where decomposition of organic matter is going on. This is the case in the city of Munich, where the underground atmosphere is shown to have a large excess of carbonic acid, in which motion is all but *nil*. Not so, however, in those subterranean streams that supply our deep wells; for in these currents water is constantly moving to replenish our rivers.

Water, as it descends from the skies, carries with it a large volume of oxygen—34.9 per cent. This is amply sufficient to oxidise the organic matters which are ordinarily in suspension or solution. The albuminoid ammonia of sewage is turned by it into nitrites and nitrates; and if, after this purifi-

cation has been effected, there should remain any germs of living organic matter in the water, the nitrites and nitrates are themselves again reduced by oxidisation, and the organic matter destroyed. This is a beautiful provision of Nature, by means of which danger from accidental contamination is reduced to a minimum. The deep well waters of the chalk district contain a considerable quantity of nitrates and nitrites at their point of origin; but after use as a water supply, and discharge into a common sewer, no evidence of their presence can be obtained, for they are immediately destroyed by the organic matter which they contain. It thus happens that, if germs capable of setting up disease find their way into a subsoil in which carbonic dioxide is in excess, mischief may result; but if it is water which has fallen as rain on an extended surface, and that water, as a matter of course, contains an excess of oxygen, all chance of continued life in the germ is taken away; it is either oxidised by the oxygen, or reduced by the nitrites, and no evil is likely to arise on an extended scale. We may thus go to deep well waters which contain free oxygen and nitrites, with every confidence that no germs of disease are lurking within. If, therefore, we have a supply from a pure source, and prevent contamination arising in its distribution, we shall be as safe as it is possible for human arrangements to be.

The last and most important point for con-

sideration is the quantity of ammonia which exists in a given specimen of water. The division into free and albuminoid ammonia is now well established, and the method of determining this by the Wanklyn process has been accepted as the best way of arriving at the sanitary value of a potable water. Ammonia ought not to exist more than in the second place of decimals in parts per million. If it comes into the first place, you may condemn the water as of decidedly suspicious character. It is well to bear this difference in mind, because it occasionally happens that parts in a gallon are mentioned and compared with another analysis, in which parts in 1,000,000 or 100,000 are quoted. I have known eminent men quite deceived by this, and arguing on the assumption that a water was pure because the quantity of albuminoid ammonia was in the second place of decimals in parts per gallon, whilst it contained in reality 14.28 times more than the water with which it was compared, and was actually a bad water. Wanklyn's process converts the nitrogen of organic matter into ammonia. The albuminoid ammonia represents that part of the ammonia which is obtained from the decomposition of albuminoid matter contained in the water, and which must have been mainly of animal origin. It must not pass beyond the second place of decimals in parts per 1,000,000. If it reaches the first place, it is bad, and must be condemned as a potable

water. Albuminoid ammonia represents ten times its weight of dry organic matter, or 40 times its weight of moist organic matter; 1-10th grain in per 1,000,000 represents 4 grains of moist organic matter; 40 grains of moist, and 1 grain of dry organic matter will correspond.

It is by considering all the points as to chlorides, nitrates, and albuminoid ammonia that we are able with confidence to assess the dietetic values of a given specimen of water. The free ammonia has not the same significance. It is always present in small quantities in most waters, especially rain water; but if excessive it has probably been derived from the decomposition of urea. Free ammonia in small quantities, without excess of chlorine, is not of so much moment; but, if chlorine is above the regular amount, then the presence of free ammonia is suggestive, and its source should be sought for.

Wanklyn has worked out a theory as to the quantity of free ammonia derived from urea which should be found in London sewage. Taking, he says, the water supply as 30 gallons per head per day, and the quantity of urine as three pounds per head, the sewage will contain one per cent. of urine. It undergoes rapid fermentation, and yields carbonate of ammonia. Estimating sewage to contain one per cent. of urine, and urine as containing one per cent. of ammonia, sewage should have 0.01 per cent. of ammonia, or 100 parts per million. He says that most

samples of sewage fall short of this quantity. I should mention that the River Pollution Commission have recommended that two parts of organic carbon and 0.3 of organic nitrogen in 100,000 should condemn its admission into any stream, and it would therefore be unfit for consumption for drinking purposes; at the same time, they do not imply that a less amount would constitute a potable water. If a water is free from albuminoid ammonia it may pass as pure, despite a small quantity of free ammonia and chlorides; but, when the ammonia equals 0.05 per million, then the amount of free ammonia becomes an important element in the calculation.

A good water, therefore, if hard, should not contain more than 30 grains per gallon of solids. It should not have more than 3 or 4 grains of permanent hardness; the temporary may range from 16 to 20, but the permanent must not be above 5 or 6. There should not be more than 1.0 to 1.5 of chlorine per gallon unless the water is from a marine formation, in which case the presence of chlorine, unaccompanied by excess of ammonia, is not of consequence. Free ammonia should not exceed 0.05 in parts per million, unless albuminoid ammonia is entirely absent; whilst if the latter reaches 0.05 the water is most decidedly suspicious, even although the free ammonia is small in quantity. If there is an amount approaching 0.05 of both kinds, the water must be condemned as quite unfit for dietetic purposes.

Having determined what are the qualities required in a pure water, our next consideration is from whence is the supply to be obtained, and who is to be responsible for it.

I shall restrict myself to the supply as required for large towns. I need not go into the question as to the urgency for such supply of water; it is a necessity of life. It cannot be omitted from our list of wants, and the conditions of society are now such that the congregation of individuals into towns, and the aggregation of towns themselves in this country, leads to the contamination of water-courses. A small family may be supplied by a spring from some uncontaminated source; but when individuals collect around that spring, and contaminate the subsoil in its neighbourhood, they pollute the water with matters which tend to produce much evil.

Dense populations are generally found near to a porous subsoil, and near to rivers, or on a sea shore. Rocky formations are not the most frequent upon which great cities are built; and where people live on a damp open subsoil, with no artificial water supply and without efficient drainage, the surface wells upon which the people depend for drinking water are certain to become largely polluted by those kind of fœcal impurities which contribute to render a place unhealthy. It is under such circumstances that it becomes the duty of the Local Authority to provide a proper water supply for their constituents, and under

Clause 46 of the Public Health Act they may be called upon to provide this necessity of life by the people themselves; but they are not allowed to place themselves in competition with private companies. This exigency for the action of a community may arise from a variety of circumstances:—

(1) Thus, there may be no natural supply of water to be had in the place at all, in which case some will have to be brought from a distance.

(2) That which is there may be loaded with mineral matters that are injurious. A water with a large quantity of Epsom salts in it is not a pleasant potable water; 7 to 10 grains of a magnesium salt is likely to produce a tendency to diarrhœa and irritations of the intestinal canal, indigestion, &c. The presence of magnesium salts are also supposed to be the cause of goître. The prisoners in Durham Gaol were at one time affected with swellings of the neck, and the water supply was found, on analysis, to contain 77 grains per gallon of magnesia and lime salts. The presence of iron and lead, or even of any metals, should prohibit the source as one of supply. A water which is chalybeate may be at times beneficial, though not always palatable, and lead colic would be unbearable if a whole city were subject to it.

(3) Peaty water—that is, a water from boggy ground, and which is loaded with decomposing vegetable matter—is to be avoided. It gives rise

to diarrhœa, and the malaise belonging to marshy districts. It is thought that ague, dysentery, and intermittent fevers of all kinds have their origin in water which is affected by some vegetable decompositions.

(4) Last, but not least, water rendered impure by animal, or indeed by any organic matter, is to be shunned. The evidence upon this point has accumulated to such a degree as to render it quite incontestable, and it is unnecessary for me to occupy your time in producing proof of the same. Diarrhœa, dysentery, enteric fever, dyspepsia, and numerous other diseases may be entirely caused by impurities in the water supply, and it is the duty of the Local Authority to take care that risk from such diseases shall not arise.

It having been determined that a water supply must be obtained for a given district, we may now ask, Who is to provide it? Usually the want has been met by the formation of a company, who have subscribed their money and erected the works as a commercial speculation. In former times, in our own land, the necessity for water produced the natural results of good profits upon such undertakings. When it was seen that persons taking water from a company escaped those evils which befel citizens who did not use the same supply, there would be no lack of customers, and no lack of enterprise to supply the staple. But works cost money, and a profit was also wanted. How were those to do who had no money, or who

could not afford to pay the charges lawfully demanded for the necessity itself? They either went without or stole from those who had it.

Then came, also, the demand of the Local Authorities for water for public purposes; and at length power was given to the companies to levy a rate for, and collect a tax from all persons using the water, at a certain amount in the pound upon the value of their property, whilst the Municipal body was empowered to charge the expense upon the general rates for such as they required for public purposes. Still, many houses, especially those inhabited by the poor, who lived in single rooms or in small cottages, were frequently either without water, or their supply was so polluted as to be unfit for drinking purposes. Then the clause was enacted which enabled Local Authorities to compel the owners to lay on water to such cottages or poor houses, provided it could be done at a small cost per week. At the same time, power was given to the Local Authority to erect waterworks and supply water for themselves, provided no water company was already in existence. Parliament, however, was tender of vested interests, and would not allow any interference with such rights without due consideration. As a body, they were not so convinced of the injurious result of a want of water as to determine that it must be given at all costs. As the law now stands, if a water company exists in a given district, and the company is able and willing to supply

it to the district, the Local Authority cannot themselves be the direct channel through which the water shall be supplied, but a commercial company is charged with the duty. If such trading body has not been already formed, the Local Authority may then provide the necessary works, and raise the required funds, charging the rates of the district with the cost of the same. If the undertaking could have been carried out at a profit, as the law stands at present, it would probably have been done by private enterprise; if it could not be done profitably, then it may now be done by the Local Authority, should the majority of the inhabitants think fit.

The rapid increase of population around our centres of industry renders the formation of such works a matter of absolute necessity; and the great point under consideration is, whether they should be in the hands of a private and commercial body at all, or be transferred compulsorily to the care of the Local Authority. Our successors in the twentieth century will probably wonder at the apparent absurdity of placing the power of providing a necessity like water in the hands of a commercial body. Apparently we might just as well contract with a company to carry on a war with an enemy, or enter into an arrangement with a board of directors that they should keep peace between us and our neighbours on the Continent. But, to make the analogy complete, it must be provided that it should be of

very little consequence to the company even if war did break out between us and the country in question. At present, however, the advantages of companies in the matter of water are about equal with that in which the power is exercised by Local Authorities—that is, in a large proportion of our towns.

The object of a company is to supply water at the least cost to themselves, and to get for it as much as the Act of Parliament under which they exercise their powers will allow. At present, they are neither bound to supply a pure water, nor to supply it to those who cannot pay for it; and yet it is as absolutely required for the poor as for the rich, and it ought to be pure. Under these circumstances, we ask at once whether it would not be better for the power always to be in the hands of the Local Authority? I think it would, as an abstract principle; but it does not follow that such a plan would work any better under present circumstances than when the water is provided by a company. The object of a company is to keep up the price of the article, and to supply as little as possible. They endeavour to supply it pure, if it is convenient to do so; but, like the proverb as to getting money—honestly if you can, but get it—so with water, supply it pure if you can, but if not, impure. Water must be had for the customers, but it will not be supplied without payment. Are these disadvantages greater than those which would follow if the management were

in all cases in the hands of a Local Authority? The members of a Local Board are elected by the ratepayers, and they are generally returned with but one object—viz., to keep down the rates. That is the first article of belief in the mind of the municipal elector who is active in electing our Local Boards. Any blatant busybody who is plausible can, by pandering to the petty economy of the noisy ratepayers, get into office on a Town Council or a Local Board, and will often displace the quiet worker who has learnt his business, and made himself acquainted with the requirements of the district as regards health. The man who does his best to promote the health of the poor in his district is ousted, and an ignorant local agitator returned in his place. The result is shown in ineffective public works, and the election of incompetent managers at small salaries to carry out duties which require men of intellect and ability; this is one of the great drawbacks of Local Self-Government.

As matters stand at present, I see advantages in companies having the management of waterworks which Local Authorities cannot have, and will not obtain legally; the former should be compelled to provide as much pure water as the State requires, and be pecuniarily responsible if they failed to do so, whilst the dividends to be paid should be limited by law. Their accounts should be audited by a Government

auditor, in a manner similar to those of Local Authorities. They should also be compelled to supply a sufficiency of water at the demand of the Local Authority. These regulations, if legally enacted, would obviate the evils which now arise from the works being in the hands of a commercial company, whilst the evils of Local Self-Government would not endanger the lives and property of the inhabitants. The method I propose would be a middle course between the two extremes.

In the case of great cities like London and Manchester, the area of representations is so much greater that a small man has not the same chance of being elected on a Board of Management, to the exclusion of the more educated one; and in such places the water supply should undoubtedly be in the hands of the Corporation. I do not suppose that the water would be of superior quality, or that better arrangements would be made for its distribution, for, after all, the same class of men are elected directors of water companies as sit upon Local Boards; but the question of payment for water supplied to the very poor would not arise as it does now, and the Local Authority could be compelled to afford means for providing an ample supply for all persons, and at all times, without on every occasion counting the cost. But, even then, there should be a right of action against the Local Authority if they were to supply an article which gave rise to mischief to those who consumed it.

The method of distribution of water is very important, and requires to be seriously thought of. We will suppose that the works belong to either a Corporation or a body of shareholders; that the water is from an undeniable source, and abundant in quantity; and we have to advise whether it shall be stored ready for use or not. If it has to be raised to any height, is always at command, and steam power always ready, it is not necessary to store more than sufficient for one or two days' consumption; but, if the source is uncertain, it may be necessary to store sufficient for several weeks' supply, and then a reservoir, which shall not be liable to receive contamination from any source, has to be constructed. This is a point to be determined by the engineer. I am not intending in any way to encroach on his province, and, therefore, shall give no opinion as to the method in which the works should be constructed. But, if a question should arise in the engineer's mind as to whether in a given case an intermittent or a constant supply of water should be afforded, no doubt on the matter should exist in yours; nothing should be allowed to interfere with the constant supply, or induce you to consent to an intermittent one in its stead. That should be a "*sine quâ non*" of all waterworks; and, if a constant supply cannot be obtained without storage, reservoirs must be constructed. Still, it should be known that great dangers may lurk in a constant supply arrangement, if by any mischance the supply

should be made to act intermittently. The service must be always constant. How to make it so is the engineer's duty. You will understand that, by a constant supply, I mean that the service-pipes should be always charged, without the occupier having to take the supply from a cistern. Water for dietetic purposes should come direct from the main, and upon that main there should always be a pressure sufficiently strong to ensure delivery at the top of a house if necessary, and sufficient also to prevent regurgitation. An intermittent supply is that which is delivered for so many hours only (perhaps one or two), by means of which a cistern of a certain size is filled, and intended to last for one, two, or three days, as the case may be, or until the turncock thinks proper to renew the supply. If by any accident that official does not come, the district is without water altogether; or if the ball-cock, which regulates the supply in the cistern, does not act, the cistern is not filled, and the same result follows; or, what is still more common, if any of the taps which communicate with the cistern are out of order, so that the water escapes and runs to waste, there is no water for the household until the turncock comes again.

The dangers which attend upon an intermittent supply, therefore, are much greater than those which belong to a constant one. First, there is that of being without water altogether; then there is the danger of contamination which arises from

a dirty storage; cisterns at times become repositories for other things besides water. They are often placed in most objectionable positions in the houses of the rich and well-to-do, as well as those of the poor; they are certain to be exposed to unwholesome influences in many different ways. An intermittent water supply is therefore one of the things to be avoided in new districts and to be removed in old ones. Quite as dangerous are constant supply fittings, if they are made to do duty for an intermittent system, unless the first canon law with reference to water has been religiously observed. That canon law is that "*no water-pipe shall come into contact with any sewer. That the sewers and water services shall be kept perfectly distinct, and no possibility of inter-communication of contents arise at all.*" As at present carried out, interchange of gaseous, if not of solid contents, is very common. If cisterns are in use, it often follows that the overflow-pipe is made, for convenience, to discharge directly into the sewer. The overflow is supposed to be trapped by a bend or syphon. The syphon can only be trapped in the event of the overflow being required by reason of some mishap. It follows that there is, in effect, no trap at all; the sewer air rises, and floats over the water in the cistern, and the purer the water the more certain it is to absorb the gaseous products of sewer decompositions, together with any germs of disease which it may bring up with it. Every time the

water-closet is used the pipe which conveys the water from the cistern to the water-closet empties when the flushing ceases, and then refills with air from the pan of the water-closet; and each time that the place is used the air rises, and all albuminoid matters in it are absorbed by the water in the most rapid manner. For this reason, no dietetic supply should ever be taken from a cistern which supplies a water-closet, even if it should be protected by a so-called bibcock, an arrangement of pipe which is sure not to act when its services are wanted.

If a water-closet is not supplied from a cistern, but direct from the main, the supply-pipe is brought into immediate contact with the sewer air, or the foul air which generally fills the soil-pan of the closet. If, then, the water supply happens to be intermittent, and the pipe which conveys it becomes leaky from corrosion or any other cause, an intermittent supply leads to water contamination to a certainty.

It follows, also, as a matter of course, that soil in the neighbourhood of a water-closet is loaded with saline matters, such as nitrates and chlorides. These act most rapidly on the supply-pipe, and soon lead to decay. When a constant supply has been made an intermittent one, corrosion seems to go on more rapidly, allowing of great waste of water, and also the certainty of occasional contamination, which will bring disturbance and disorder to the functions of the

stomach, and may give rise to the production of zymotic disease. The introduction of air into the pipes promotes their corrosion; the vibration which ensues when air is allowed to enter shakes off the scales of oxide, and helps forward the fracture which is about to take place.

The character of the material to be used for the conveyance of water has to be considered. It is the custom to supply by either iron or lead. Some years since it was usual for Sanitary Authorities to recommend iron instead of lead, on the plea that lead was liable to dissolve, and produce lead-poisoning among the people; and a great number of fairly-authenticated instances have been brought forward which tend to confirm this view. The result of substituting iron, however, has not been satisfactory. It has led to an enormous waste, and also to increased liability to corrosion. When iron-pipes have been used indiscriminately, without reference to the character of the subsoil, or when brought into contact with the lime of an ordinary building, or laid in rubble, gravel, or garden earth, the action which ensues is immediate and rapid. The salts which exist in such materials exert an influence on the iron, and combine to form nitrates and chlorides with it, which, in their turn, are decomposed by the carbonic acid which always abounds in such situations. These, in turn, are converted into oxides; the pipe becomes pin-holed and pervious to water under pressure; this leakage moistens the

subsoil and saps the support upon which the pipe rests; ultimately a large hole forms, and the waste becomes excessive. If the subsoil is very porous the water which escapes does not make its power felt on the surface, but sinks into the ground and renders the whole basement of that house damp. The result is that the inmates suffer from those maladies that are produced by a damp subsoil. It is not absolutely necessary for these changes to take place in the services; they may be prevented by laying the pipe in solid and pure chalk; or, still better, by coating the pipe with a covering of about 6 inches of clay, so that all air shall be excluded in each case. This protection will effectually preserve the service-pipes from injury; but, at present, the people who lay down services will not attend to the minute details which are required to make this a successful act. Gas companies have adopted the plan of laying their services encased in sawdust steeped in tar. The same protection should be afforded to water-pipes, or else they should be thoroughly surrounded by clay. In America they have a method of lining water-pipes with a vitreous material similar to glass.* This not only preserves the water from metallic contamination and the pipes from premature decay, but prevents the loss of mechanical power by friction. It is supposed that, in a light gravel or sandy soil, 25

* These glass-lined pipes have been introduced into this country.

per cent. of the gas manufactured escapes through the joints of the mains, to the detriment of the health of a neighbourhood and the pockets of the consumers, who have to pay for this needless waste. The statement is denied by the gas companies, but the fact is self-evident to anyone who walks down a street when the gas-pipes are being taken up. In clay, however, no escape of this kind takes place.

We may ask, Why use iron at all for such purposes? It is found to be able to stand the changes of temperature better, and does not burst so readily in frosts, and it is not injurious to the consumer in the way that lead may be; but then the question of frost is a matter of expense only. Lead-piping may be protected from the cold, and need not become frozen; whilst, as regards the second objection, it has arisen mainly under a misapprehension when taken as applicable to all waters. As a matter of fact, lead is not acted upon by water which contains three or four grains of lime to the gallon. It is soft and distilled water which acts so readily on lead. When, therefore, the supply is the result of rain water storage, or is obtained from granite or clay-slate formations, or if the water contains some kinds of sulphates, lead-pipes must not be used, unless the water is limed; but, for all waters obtained from oolitic, cretaceous, or tertiary formations, which do not contain sulphates, lime always exists in it sufficient to protect lead from the solvent action of water, and it may be used

safely. The greater ease with which lead may be worked is very much in its favour. There is a patent for covering the interior of a lead-pipe with a block-tin casing. If done well, it is effectual, and the compound-pipe may be safely used; but it is very expensive, whilst, if the contiguous metals become exposed to the air, a galvanic action arises which leads to rapid decomposition, and a consequent breach in the pipe which allows of waste.

The character of the taps and other fittings connected with water supply are important matters.

The waste of water in an ordinary town is a subject which may or may not be of importance. If the source of supply is sufficiently elevated to allow the water to gravitate without pumping —if the sewers are judiciously arranged as to the quantity of sewage, so that it may be utilised without reference to quantity—then the amount used is of no moment; but, if otherwise, it becomes an element to be seriously considered.

What is the quantity which a town absolutely requires for general uses? Experience shows that an authority must be prepared to supply about 35 gallons per head per day for all purposes. Londoners use 30 gallons, but then, as large portions of the Metropolis are served with an intermittent supply, many thousands of the people have great difficulty in getting water at all.

If London received a constant supply, so that all persons could get as much as they wanted, it is probable that 50 gallons would

be required. Whether it would be used or not is another matter. Experiments carried out by the Croydon Local Board of Health at my suggestion showed that, where the fittings are perfect, the consumption among cottagers amounts to about 11½ gallons per head per day. In the better class of houses it is about 12 gallons per head. To this we must add about 8 gallons for municipal purposes—flushing the sewers, watering the roads, &c.—and the ordinary manufactures which belong to a mixed population. If the fittings are well looked after, and all the arrangements as they ought to be, 20 gallons would be sufficient; but 50 is more often used, and in some districts where the old iron fittings, which were excessively defective, continued in use, as much as 112 gallons per head per day passed through the meter used to test the quantity. In Liverpool the consumption used to be about 50 gallons, but by judicious enquiry and continuous watching the Corporation were enabled to reduce the quantity to 22½ gallons.

If, therefore, a company is able to supply 30 gallons per head per day, it is doing as much as ought to be required. That quantity equals 3,000,000 gallons for a town of 100,000 persons. The consumption for Croydon is now about 46 gallons; some of this passes away in the small hours of the night, when there is no consumption, and is wasted, and a similar amount of waste goes on during the day. It has been fairly proved

that at least half of the water raised into the reservoir is not drawn from the taps for use, but escapes through defective pipes, fittings, and taps carelessly left open.

I am not about to enter into any kind of detail as to the construction of waterworks, beyond those matters which have an important bearing upon the public health. There are many points which can only be determined by the engineer, and, as I have said before, it is not my province to trench on his domain, or on subjects which he alone will have the power to determine; but there are other points on which the public will always have something to say, and upon these the opinion of the medical adviser is generally sought, though not always followed. The source of supply is one of these points.

In all cases the source is the rainfall. All our supply comes originally from the clouds, and alters in its character according to the materials it meets with before it reaches its destination as a drinking water.

Pure rain water is not available as a perfect source. According to the computation of engineers, the roof surface from which rain could be easily collected does not amount to more than 3 gallons per head per day, and it is so liable to serious contamination from smoke and animal *débris* that it ought never to be depended on in towns. In country places these contingencies do not arise to so great an extent, and rain is fre-

quently the only source of water supply. In such cases the roof surface is increased, so that the supply is about equal to the demand when the rainfall equals 30 inches per annum. Rain water is not pure in the neighbourhood of large towns; it is tainted with volatile oils which have been washed out of the air. It frequently, if not always, contains traces of ammonia, sometimes nitric and sulphuric acids; sulphuretted hydrogen gases are also found, together with albuminoid matters, which are probably the germs which produce all manner of microscopic objects. These may be collected by an ingenious arrangement, which I explained in my previous lecture (page 75). They are washed out of the air by the rain, and in that water develop into bacteria, desmids, diatoms, rotifera, and the various confervoid forms of life which always arise in rain water if it is kept stagnant and exposed to light. It also contains carbonic acid in larger quantities than ordinary water. As soon as it reaches the soil, some of these gases and germs are eliminated. The CO_2 unites with saline earths, if they are available, and as the water sinks in the ground it becomes charged with the various matters which I have detailed to you as being present in spring or river waters. It will be the character of these extraneous matters which should determine your choice, if choice there is.

If water can be had which is only moderately

charged with such matters, and which has descended as rain on hills, and its collecting ground is free from the contamination of mines or highly-cultivated grounds, such sources are probably the best. Next to that we have the water from deep springs which is brought to the surface by artesian or other borings; and, if analysis shows them to be pure, they will never be liable to contamination, provided measures are taken to keep them pure. Water from rivers, especially when taken from those which are liable to be affected by floods, is not always safe, even if its ordinary composition is satisfactory. It may, however, be made comparatively safe by filtration ; but, unless sewage is kept out of the river from all places above the intake, filtration, to be perfectly safe, must be very carefully performed ; even then the idea of drinking filtered sewage is not pleasant. The most common source of water in a country place is a surface well. This may be safe enough for a single house, or even for a few houses, if it is in virgin ground, and not in close proximity to a cesspool or any other receptacle for manure, and if it is arranged in such a manner that no subsoil drainage can find its way into it.

A clear space of one hundred feet at least should exist between the well and any drain which carries sewage ; even the drain which conveys drippings from the pump should be so arranged, and constructed of such impervious

material as will not allow of any soakage from it into the well. So many things are taken to the pump to be washed that, if this necessary precaution be neglected, and the well is in close proximity to the pump, the probability is that the washings, whatever they may be, will find their way into the well; and if it happens to be the washings of an animal, or of any diseased product, mischief probably will arise to all those who may drink water from that particular well.

These general hints will give an idea as to the best sources of supply, bearing in mind that the purest water is that which is nearest the point of rainfall; and, the more cultivated the soil from which it is collected, the less pure it will be. Elevated tracts of country, hills, moorlands, heaths, and downs afford the best sources; and, if drawn from rivers liable to floods, the intake should always be above the situation of any collection of houses. If collecting grounds are used as reservoirs, they must be protected from the possibility of contamination, and all reservoirs in the neighbourhood of towns should be covered. Arrangements have to be made at the same time for overflows, and these overflows must not communicate with any part of a sewer system. The dome of the reservoir should ventilate most freely, so as to prevent any chance of contamination, or even the possibility of the water being covered with air in which CO_2 is in excess.

The atmosphere of water is a subject that hitherto has not had its due attention. It is most probable that a change in the constituents of the air of underground currents has had something to do with the spread of epidemics by means of drinking water.

Should water be filtered, and will filters take out objectionable matters? These questions will be often put to you by those who have no scientific knowledge. If water requires filtering, it is unsafe for use, and another supply should be sought for, and provided, if possible. If this cannot be obtained, then a filter will reduce the evil which may exist in the water, but will not entirely remove it—at least, such filtration as is most likely to be used. It will take out all matters in suspension, and will arrest nearly all animal life, and all products of vegetable growth which may be there; but it will not remove matter in solution, unless it is acted on by something like the magnetic carbide filter, or some other that promotes chemical decomposition. Charcoal makes the best filter, and animal charcoal is in every way preferable, as it exerts a chemical action, which may be sufficiently decided to purify slightly impure water most efficiently.* Filters may remove some of the salts, but the effect is temporary, and after

* It is fair to state, however, that the River Pollution Commissioners strongly condemn the use of animal charcoal filters.

a time the filter becomes clogged and incapable of oxidising the contents, when all saline matters and other impurities in solution will pass through the filters unaltered. I am suspicious of them myself, from having met with instances in which serious consequences have apparently followed from trusting too much to them. I would rather change the supply, if it could be done, than trust to filters, unless great care and judgment is used in their employment.

In one large establishment (Royal Patriotic Schools), the authorities of which consulted me as to the causes of certain epidemics which had appeared among the inmates, it was found that the filtered water was more impure than the supply itself before it passed through the filter. The filtering material consisted of broken shells, sand, and charcoal; it had been in use without change for some time, and had arrested much organic matter; the latter, after a time, had then decomposed and polluted the incoming water. Filters require much attention, and the material should be frequently changed if they are to be safe agents. The process of filtration must not be hurried, and pressure upon the filter must never be high; a few inches, or at most one foot, is quite as much as should be allowed. The speed with which the water passes through should be slow, and at times the filter ought to have a period of rest, so that air may enter into the interstices of the filtering medium, and assist

that oxidising process which the filter promotes. This action cannot go on unless there is an intermission in the working of the filter. It is upon this power that the principle of intermittent downward filtration is founded, and which is recommended by Dr. Frankland for the purpose of purifying sewage. I shall have to speak to you more at length upon this point in my next lecture. Alumina salts have been used in Eastern countries to purify water; they are sometimes efficacious, but are not always reliable. It has also been most broadly stated that motion will quickly render impure water pure—that even water into which sewage has been poured becomes completely purified after a run of 10 or 12 miles. This statement has been submitted to the test of experiment. Polluted water of a known degree of impurity has been passed in a miniature stream in such a way as to be in contact with air, and so arranged as to represent a run of 20 miles. The water has then been analysed, with the result of a slight diminution in impurity. It has been made to traverse a distance which has amounted to nearly 200 miles without any great diminution taking place. Still, motion and contact with air—combined with the influences which are brought to bear upon rain water by living things, as fish, animalculæ and vegetable growth—tend very much to reduce pollution; and, although it will not be sufficient to render impure water potable, it will materially assist in preventing

any nuisance arising to the neighbouring population from such contamination.

In considering the water supply which a given district can afford, it is necessary for us to have distinct information as to the rainfall of the district, as upon the amount of rainfall will depend, in a great measure, the power of deep wells, or the feeders of a given stream, to yield a water supply. Those districts which are in the neighbourhood of hills and moors, that are comparatively uncultivated and uninhabited, are in a much more favourable condition than those which, like London, are surrounded on all sides by thickly-peopled districts. Even the rain water, in such cases, is seriously impure. It has been proposed to obtain a water supply for London from different water-bearing strata which exist in its vicinity; and certainly the chalk hills north and south of the Thames contain a supply amply sufficient for the purpose, if proper means were taken for its arrest and its repurification after use. I will illustrate what I mean by reference to the valley of the Wandle, which has a collecting ground for that streamlet of about 50 square miles.

The chalk hills which rise about Godstone and Merstham to 700 or 800 feet above high-water mark are sponges which suck up an immense quantity of water—so much so, that the storage power of a cubic foot of chalk equals $2\frac{1}{2}$ gallons. The average rainfall upon this district is 26 inches, rising sometimes to 34, and, in times of

great drought, falling to only 18 inches in the year. Now, each inch of rainfall on those hills and in this district supplies 754,000,000 gallons. The water-line in these chalk hills rises and sinks according to the rainfall, the water itself being always on the move, and never stationary. Mr. Lucas, who has studied the water-bearing power of the valley of the Wandle, states that to tap the water-line in the chalk to the extent of 3 inches would yield a supply of 20,000,000 gallons per day for a year, and that no drought has yet occurred sufficiently long to drain the chalk reservoir. The Croydon Waterworks are taking 3,000,000 gallons daily, and this drain, which has been continuing for nearly 20 years, has not affected the springs that supply the head of the Wandle in the least. At the same time, it is to be feared that a long-continued drought, extending over two or three years, might injuriously affect the supply. It has been calculated that the summer evaporation from the soil equals 14 inches, and that 3 inches of rain are required to make up for loss before sufficient percolation can take place to reach the level at which the springs were standing at the end of the dry season. This leaves barely 9 inches for use. The quantity lost by evaporation could be easily calculated if the dew-point were registered at frequent and regular intervals, and this compared with the temperature. In some seasons the water-line will be lowered much more rapidly than in others,

and the water-bearing strata more certainly affected. It may be that the more perfect cultivation of the districts near to London may interfere with the power of the downs to supply water, and much has yet to be learnt on this matter.

Mr. Evans, from a series of long-continued experiments, concludes that 16 inches evaporate; if this were so, it might happen in very dry years that the valley of the Wandle would only have at most a single inch of available water supply, or even less. An inch gives 754,000,000 gallons, whilst the town of Croydon is taking 1,000 million gallons in the year. This view of the case indicates that the output of springs in the chalk should be jealously guarded, and no greater demand made upon them than they are able to bear. Hitherto the springs which supply the Wandle have never been known to dry up; but, if greater demands were to be made upon the underground reservoirs than the hills could yield, it is quite possible for the supply to fail when it is most wanted.

The water-line at Croydon is 120 feet above ordnance datum; at Wallington it is 130. The angle or gradient at which the water stands in the chalk hills varies in its rise from 10 to 40 feet per mile. There is a gradual fall in the gradient itself whenever a demand is made upon a particular district for a fresh water supply; and this fall continues until the friction which occurs

in the passage of water through underground strata is overcome. The level then remains unaltered as long as pumping continues. When it ceases, the water-line rises to its original position; but the level may be lowered if the demand has been great, and no fresh rain supply has fallen, because the storage may have been diminished so much as to have affected the whole quantity in the natural reservoir to a perceptible degree.

ON SEWERAGE.

Sewage—Quantity Produced—Dampness of Foundations—Drains and Sewers—Water-closets and the Dry System—Water System Preferable for Towns—Sewers a Necessity for Urban but not for Rural Districts—Essentials of House Drainage—Trapped Gratings—Kitchen Sinks—Foundations Impervious to Damp—Soil-pipes, and Ventilation of—Sewer Gases, Organic Germs, and CO_2—Water-pipes and Sewers—Back Drainage, Combined and Separate—Subsoil Dampness, and Evils of—Surface Water of Urban and Rural Districts—Rainfall to the River and Sewage to Soil—Overflow Sewers, and Capacity of Outfalls—"Divide et Impera"—Elongated Cesspools—Volume of Sewage should be sufficient to Ensure a "Scour"—Temperature and Ventilation—Gratings—Financial Value of Sewage—Fallacies Concerning—Irrigation—Quantity of Land Required per Population—Local Authorities have to Pay Fancy Prices for Land—Aggregate Amount of Wealth which could be Saved to the Country—Equivalents of Sewage to Rainfalls—Capacity of Land to deal with—Power of Soil, Air, and Vegetation to Purify—Disease Germs and Vegetation—Supply of Sewage should be Regulated by the Digestive Capacities of Soil and Vegetation—Practical Experience of the Dry System—Benefits of at Waddon—Slop Water.

I SHOWED you in my former lectures that we ought to convey the water into the house on the constant system, and that it should be always ready for use. Thirty gallons per head per day was mentioned as a quantity necessary to be provided. There must also be means to

convey this large quantity of water away from our houses. What is to be done with it? Even if there is no water company, and the supply is drawn from a well in the garden or an adjacent stream, in smaller quantities, what is to be done with the waste?

From what I have already stated you will have learnt, if you did not know before, that there is urgent necessity for the foundations of a house to be dry. The house being the unit of sanitary work with which we started, it is necessary to ask how this dryness is to be effected, when such quantities of water are in constant use? Without water we cannot have health; and with it, if it is kept near to us in a polluted state, our health will equally suffer. I have shown you that dampness in walls is a source of evil, and that wet foundations are to be especially avoided. Dryness in foundations of houses is essential; and if thirty gallons of water per head per day is a present requirement, so also are house drains for the purpose of removing that water from our dwellings to some other locality, when it has served its purpose. Each house, therefore, must have its own drain in communication with the kitchen sink and all waste-pipes for the purpose of conveying away bath and other dirty water from our chambers. Hence it appears that house drains as well as a water supply are necessities. It follows that sewers in the public streets are equally so. It is impossible for a number of houses in close proxi-

mity to continue habitable unless some means are taken for the purpose of carrying away dirty water. We may take it for granted, therefore, if a people wish to be clean and free from the evils which follow from residence in a marsh, that public sewers are vital necessities where houses jostle one another, and there is no elbow room for gardening operations, by means of which dirty water may be both purified and utilised. Having decided that there must be sewers, in order to provide us with a silent highway along which all dirt capable of being dissolved or suspended in water may be carried from the dwelling to its proper destination, it is often asked whether they should be used for the conveyance of human excreta, or whether that should be kept out of them and dealt with by some other method? Are water-closets necessities or not? If water-closets should be superseded, we must still have sewers, with all the disadvantages they may produce; whilst, if we abolish them, we have only another system for conveying excrement, which is equally liable to break down and bring evil if it is not most carefully and incessantly attended to. A long-continued observation of the evils, as well as the benefits of both dry and water systems, has satisfied me that, as far as towns and cities are concerned, the only feasible and satisfactory plan of dealing with human excreta, if you can command a proper water supply, is by means of water-closets; and, as a natural sequence, sewers

must be used for human excreta. It has been found from observation that the water-closet necessitates an extra daily supply of water, amounting to four gallons. The extra four gallons per head of water, which must be forthcoming if water-closets are used, might be a serious objection, and still more serious the way in which that extra four gallons has to be disposed of after having been used ; but these difficulties are to be overcome—they are not so great as those which arise from the dry system, or any other that may be adopted. The water-carriage system will be found most suitable and convenient for dealing with excreta, whilst all the dangers that result from its introduction into a town are capable of being completely remedied at a moderate expense, provided proper means are taken for the purpose.

If a correct plan be initiated, all the appalling difficulties which are supposed to belong to the water system vanish into thin air. The requirements of water-carriage are good workmanship, plenty of water, and capacity to deal with it after it has been used. If there is plenty of water, and a thickly-peopled district, so that the sewers are always in full working order, it necessarily follows that no stagnation will occur. The sewers will not run dry, and you may be satisfied that no evil will arise from them, provided that the points to which I shall draw your attention are properly attended to. Sewers are a necessity

for towns, and the water-closet plan is the best method that can be used for the collection and removal of excreta for such towns, if certain contingencies are capable of being met. This is not the case, however, with villages. I do not think it a wise course to introduce sewers into a sparsely-populated district; they engender worse evils than they remedy when they are also made the receptacles for fœcal evacuations. Every house standing in its own grounds, every cottage with a garden attached (and it would be a great thing for our country if every cottage and every house had its half acre of garden at the rear) for the cultivation of those fruits and vegetables which are necessary for all—I repeat that every house standing in its own grounds in a country district should utilise the fœcal evacuations of its own inhabitants, and not allow such matters to get into any sewer or house drain, to be retained there for the production of future mischief, or stored in some cesspool, as is the usual custom when the water supply is not very far from the dwellings of its users. I am strongly in favour of a dry system for villages, and gentlemen's houses which stand in their own grounds. The nature of this I will detail to you when I come to that part of my subject. The principal reason for this opinion is, that a house drain with a long stretch of pipe from the house to the main sewer must be frequently without a current of water. There must,

from the very force of circumstances, be many hours during which nothing is conveyed along the sewer, during which time it becomes comparatively dry; stagnation arises, and opportunities occur for the production of evil matters which are injurious to those who live in close proximity to them. The excreta of an individual suffering from some infectious disorder is not necessarily hurtful in the state in which it passes from the patient. Indeed, in the majority of instances, it is comparatively harmless; but, if it be kept stagnant for ten or twelve hours, mischief will arise. Should it pass down the sewers and be conveyed away to the country, there will be no change of an injurious character whilst it is kept moving; but if movement be arrested, and any stagnation occurs in the house drain at an angle or a depression in the pipe, you have a focus for the production of fresh disease of a similar kind, on a much larger scale, should it find a population upon which to execute its ravages. The limited amount of sewage from one house, or from two or three houses, on a long line of sewer, is a disadvantage which can be overcome by no other way than by providing a constant current of water through the sewer. In the case of villages, if we keep human excreta out of the sewers much evil can be avoided, and local epidemics frequently prevented.

Coming back to the unit of sanitary work in

the town, there are two canon laws with reference to the house drain which are absolute:—

(1) No sewer or house drain shall have any direct communication between it and the house, except that which constitutes the soil-pipe of the water-closet. Every other communication but that one shall be by indirect means only.

(2) No sewer shall be allowed to pass beneath the basement of any house.

To introduce a sewer beneath a house is to create a passage along which matters and things will force an entry. It is to make a secret way by which a hidden enemy assails the inhabitant unawares, and must, some time or other, from the very force of circumstances, bring evil upon those who live in that house. The natural decay, and those alterations which occur in material things, will bring about changes that lead to this assault from below. It ought not, therefore, to be tolerated, except where it is impossible otherwise to provide for drainage without such a sewer; in these cases provision should be made for such an emergency. The sewer, under these circumstances, must be laid on concrete, and fully protected by impermeable material above it. The first canon law is absolute; it follows that, if it be obeyed, there will be no channel by means of which products arising from the decomposed contents of sewers can find their way directly into the house.

The kitchen sink, the housemaid's waste-closet, the bath waste, and receivers of urinals ought all to pass directly through the outer wall, against which they should always be placed. They should then flow on to a grating which covers a trap, so arranged as to be effectually sealed against the exit of sewer air. If, however, by any accidental means the sewer is blocked, or the trap be out of order, then the discharge of sewer gas, if it takes place, would be into the open air, and the evil of such a discharge will be reduced to a minimum. It is not necessary for such discharge-pipes as I have recommended to be sticking out of the side of the wall, and hence liable to the dangers which follow from such an exposed situation. They may be placed beneath the level of the ground and discharge into a chamber a foot, more or less, in cubical capacity, provided the container is covered by a perforated iron grating which will allow of a free exchange of air, whilst the trap below is so arranged that it can be examined every day and cleared from accidental impediments. Kitchen sinks should always be on outer walls, and a receiver should be placed in connection with the container, which should arrest the fatty matters going from the sink. These containers should be so placed as to be capable of easy clearing as often as may be necessary. They should be covered by a stone, easily moveable, and so placed as to be not liable to receive any other

matters than melted fat and those extraneous things which are likely to be arrested by it. In no case should it be possible for human excreta to get into the fat trap; that is, no kitchen sink should be so close to a soil-pipe as to prevent the formation of such a trap independently of the sewer, or allow the contents of any sewer to pass through the trap. If any distance exists between the sewer and the kitchen drain, the branch should be ventilated by a pipe in a manner similar to that which is effected by means of Pott's Edinburgh air-chambered syphon trap. If such an one be used, there is no chance of evil getting into the house directly from the sewer.

It is very common for surface drains to be formed in the basement of a house, and drains are often put into areas for the purpose of enabling the kitchenmaids to swill down the stone floors. These are wrong; if the basement of the house has been properly constructed they are not necessary, and if put in at all they should communicate with the house drain by an indirect channel only; they should be connected in such a way that it should be all but impossible for the intercepting trap to become dry.

All houses should have a dry area around them outside the foundation of the house, which should be ventilated by gratings outside; and, if this area is arranged so that no air can get into it from any sewer, so much the better. If, in addition, the foundations of the house have been

so laid that no moisture can rise upwards by capillary attraction through the bricks—if a course of impervious material, such as slate or asphalte, be laid so that nothing can rise above it, the house will then be kept perfectly dry and free from the chance of sewer contamination.

The soil-pipe of the water-closet should be kept outside the building, and, if the water-closet itself is erected outside, so much the better. It is absolutely necessary that it be placed on an outside wall, and communicate directly with the open air by one window at least. Two openings are better than one, as by that means a thorough ventilation is established independently of the house. Soil-pipes should go as directly into the sewer as it is possible for them to do.

There should be few angles (none if possible) between it and the sewer. If angles must come into its construction, they should never approach nearer to a right angle than 45 degrees. The water-closet is connected with the soil-pipe by a short limb which exists between the trap and the soil-pipe, above the level of the water in the trap. It should have a ventilator between the trap and the soil-pipe nearly equal in diameter to the soil-pipe itself, and should pass upwards as nearly straight as can be effected, going into the air above the level of the topmost windows of the house. It may not be always necessary for this shaft to be carried up very high; it may open on the outer wall, and be kept flush with the wall if

it is not in a closed court, if there is a free circulation of air about the place, and no windows in close proximity. By this means the soil-pipe will be properly ventilated, a current of air kept moving through it, and no lurking place will remain for the production of noxious matters. If every soil-pipe is ventilated in this manner, and an opening provided for the escape of sewer air from the house drain, it will not be possible for evil to arise; whilst the conveyance of the products of sewage fermentation or decomposition into the upper regions of the atmosphere will bring about that dilution upon which safety depends, since dilution means destruction.

Sewer gases only produce mischief when they carry particles or germs of organic matters capable of reproducing themselves in a suitable soil, or some potent matter which can alter the blood of the recipient. These germs or particles of matter are only pregnant with evil in an atmosphere which has an excess of CO_2, and in which moisture is above the average, whilst extremes of heat and cold check their reproduction. Diminish the excess of CO_2 and moisture, expose them to changes of temperature, and their vitality is lost. These are the points which are gained by sewer ventilation, and these are the results we must aim at in sewering a town.

It happens that perfection is difficult to accomplish; to have sewers which shall remain clean, and not be at any time sewers of deposit,

seems to be beyond attainment in our times. Whilst striving for an ideal perfection, we must also guard against possible contingencies which imperfections produce. It is right, therefore, under most circumstances, to introduce between the house and the main sewer a valve or trap which shall prevent the return of foul air from the main. Like the valves in the veins, these traps will allow of everything passing downwards, but when regurgitation arises they will close and prevent a reflux. These valves are now constructed on a somewhat similar principle to that which is adopted in Arnott's ventilators. There are many objections to them, and they are likely to be sources of trouble unless looked after; but, if they are arranged on a proper method, and a ventilator, with a shaft, placed on either side of them, so that the valve can be easily examined, they will afford a most efficient protection against the spread of evil from the main sewer—that is, from the public sewer into the private house. They must be as constantly supervised as the fat trap or the general trap outside the kitchen sink, and then their safety will be ensured. In the case of small houses with short drains and a plentiful water supply, these arrangements are all unnecessary if the soil-pipe is properly ventilated and the canon law with regard to sewers is observed—viz., no sewer in direct communication with the interior of the house, and no water-pipe which conveys water for dietetic use in direct con-

tact with the sewer. Sewers and water-pipes, in all cases, should be kept as far from each other as possible.

The next point for consideration is that which determines the course that house drains shall take.

Shall the sewers be in the front of the house along the main street, or shall they be arranged on the principle which is called "*back drainage?*" It is usually and properly the custom for the main sewer to pass along the centre of the street, and for the houses on either side to drain directly into it, each house having its own proper drain. But I have already laid down the principle that sewers should not pass beneath the foundations of the house; if, then, houses are built together in rows, how is this to be prevented? How are we to comply with the recommendation, especially as water-closets are generally in the rear of the house, and back kitchen sinks are also in a similar position? If, therefore, drains are not to pass beneath the house, how are they to discharge into the main sewer? Terraces and blocks of buildings should have combined back drainage. There are cases in which this is inadmissible, and where the difficulties of back drainage are greater than those which arise from the passage of the house drain below the basement. This is the case in a dense assemblage of houses like that which exists in the city of London. But it is the most advantageous system which can be adopted in streets which consist of private dwelling-

houses, and rows of shops which are not detached or semi-detached buildings. I have said that it should be a canon law of sanitary work that all house drains be kept outside the fabric of the building. Under ordinary circumstances the passage of a sewer beneath the house does no harm, yet it is certain, at some time or other, to produce serious evil. It creates a weak point in the foundation of the house, and, as house drains are at present constructed, promotes the chance of a settlement. In the course of time the drain-pipe cracks; a little sewage escapes through the crevice, and gives rise to dampness; then further changes follow. The whole pipe drops, the joint gapes, sewage pours out into the subsoil, and the dampness of the basement increases. The inmates begin to suffer from rheumatic affections, and become liable to all the neuralgic tribe of diseases which are promoted by impure and stagnant moisture. The subsoil beneath the basement becomes soaked with sewage, and the inmates may become the victims of one or the other of the zymotic class of illness which are styled so expressively by Mr. Simon as Filth Diseases. Perhaps the cause is not discovered until the decay of the floors, and the flooding of the neighbouring area or yard with sewage, reveals the fact of a block in the drain. The discovery of the stoppage is not a necessary sequence, so long as the soil allows the sewage to soak away. I have known the state thus

detailed to exist for many months, or even years, before the real cause was discovered and remedied. The passage of a house drain or sewer beneath a house may render it quite uninhabitable long before the residents are aware of the danger they are incurring.

It must be apparent that the rules which have to be followed, in laying out the lines of drainage for an old city, are not those that should be followed in providing for the drainage of a new estate. When large buildings and piles of ware-houses exist, sewers must not be carried below them. The principle to be kept in mind is, that back drainage is the best under certain circumstances, especially if the drain passes through the property of one owner. The advantage of this plan is that the drain is materially shortened by being so made, it has fewer angles, and delivers into the main sewer more immediately, if it can be examined at any time in some part of their course by the Local Authority. It generally shortens the length of the house drain, which is at all times an important consideration. If, however, these conditions are not fulfilled, and the drain has to pass through the land of many different owners—if the Local Authority cannot examine it without trespassing, there are serious objections which may outweigh the advantages I have pointed out.

The connection between a main sewer and a sewer draining a block of houses should always

be commanded by a man-hole, which may also act as a ventilating shaft.

To resume, back drainage is advantageous if there are terraces, or blocks of houses belonging to one owner, and especially if the communication with the main sewer can be commanded by the Local Authority; but, at the same time, it should be borne in mind that the longer the length of sewer that can be kept on public ways the better it will be for the public interests, provided the length is not excessive, and the area drained is not too thinly peopled.

Is it right to admit the rainfall of the district into the sewers? This is a point frequently debated, and one upon which your opinion will be often asked. Are the sewers to be constructed so that they shall carry away the sewage proper and the rainfall together, or ought the surface drains to be altogether separate from the sewers? This is a question that cannot be fairly answered until you know the district to which it is to apply. If London, or any other great city, is the place in question, there cannot be much difficulty in answering it. The washings of the streets of great cities produce a matter which differs in no respect as regards analysis from ordinary sewage. Chemical analysis of the sewage of towns like Manchester and Leeds, which do not, or did not admit human fœces into their sewers, corresponds in a great measure with the analysis afforded by London sewage. The

washings of thickly-peopled places, of streets, courts, and even squares, must be provided for, and not allowed to flow into the nearest water-course. In such places two sets of sewers would be entirely unnecessary. The difficulties which have to be encountered in dealing with one set of sewers would be enhanced by having them in duplicate. In our large cities and thickly-peopled towns, a double system would be wrong. At the same time, the dictum of "*rainfall to the river and sewage to the soil*" is perfectly appropriate if we can keep the sewage out of the rainfall. Anyone examining the material which collects in a public street will see at once that no ordinary arrangement will effect this, and that sullage which washes down in a heavy rain from the streets is as much sewage as that which flows through the ordinary drains—at least, as far as regards its chemical composition. If disease germs find a resting-place in it, they may produce as much mischief from such a starting-place as sewage proper could do. The case is different in that class of towns which occupy the border land between dense populations and places with but few people to the square mile. The density of population in London is 41.8 to the acre, whilst Lancashire, as a county, has only 3 or 4 to an acre; Glasgow has 94.0, Bristol 37.0, Birmingham 48.0, Liverpool 103.0, and Manchester 84.5. For such towns it would be absurd to separate the rainfall from sewage proper. Indeed, rain-

fall is necessary at times for the purpose of thoroughly well flushing the sewers.

In the case of towns, with their courts and alleys properly paved, the authorities will do well to send the surface water into the sewers; but in places which, from being thinly peopled, do not require sewers, or when the rainfall exceeds by many times the cubical quantity of sewage, then there should be a separate set of surface drains to carry the rainfall direct into the nearest water-course. There may be, therefore, surface drains in one part of a district and not in another. And there are places even in London—such as the parks, and some other open spaces frequented by foot-passengers alone—in which the surface water need not be conducted into the sewer; but if animals are numerous, and scavenging indifferent, as it usually is, all surface washings should be provided for by the sewers of the district. In London the sewers are designed to carry away the surplus water at the rate of $\frac{1}{4}$-inch of rainfall every twenty-four hours, over the whole area drained, at the times of maximum flow. This is said to be sufficient for London; but, in places where the rainfall is much greater than it is in the valley of the Thames, this capacity would not be sufficient. You must look to the rainfall of the district, therefore, before the size of the sewer is decided upon.

I object to the plan of overflows for storm waters on the scale now adopted for London. It

is requisite to have safety-valves for an excessive downpour of rain, but I think a greater allowance should be made for cities than $\frac{1}{4}$-inch of rain. We frequently have a fall of $\frac{1}{2}$-inch in twelve hours. The first fall stirs up the mud, but it is the second $\frac{1}{4}$-inch which carries it away, and the water then is often more foul than the first flush. It would be more expensive, but safer, to construct sewers large enough for $\frac{1}{2}$-inch rainfall in twenty-four hours.

These are matters which fall more to the province of the engineer than to the medical man. Still, in every system, the latter should consider whether a given scheme will fulfil the requirements of a certain area. There are several points to be entertained, such as—

(1) The area of the district itself.

(2) The population contained in that area.

(3) The number of animals, as well as people, to be provided for.

(4) The character of the manufactures.

(5) The rainfall of the district, with which is closely connected

(6) The character of the district as to soil and surface levels. The side of a hill which consists mainly of clay will send off all surface water, whilst a gravel or chalk subsoil allows all but that which collects from roofs of houses and paved courts to go into the soil and soak into the ground.

(7) We must also consider the character of the water supply; the quantity available for domestic use.

(8) The habits of the people. And, lastly,

(9) The position of the outfall, and the intention as to the disposal of the sewage; whether it is to be utilised by irrigation, or dealt with in some other way.

I have already stated that, for country places and thinly-peopled districts, sewers are unsuited and out of place. The soil is close to the sewage, and to carry it away and collect it in larger quantities in some other place is a mistake. Like every other evil, it cannot be remedied by mere concentration on one spot. "*Divide et impera*" is a maxim especially useful in dealing with sewage. To take it in detail, and deal with it as quickly as possible, is a necessity of the case. The chief value of sewage as an agricultural commodity is in its freshness, whilst the great danger which arises from sewage as a factor of disease arises during the early stages of its decomposition. The principle, therefore, to be kept in view, in all cases, is to deal with it *fresh*. I wish to impress this upon you as a canon law—a cardinal point in sanitary arrangements. Delay in dealing with it means possible danger to the community among whom it is kept. Cesspools have been long condemned as highly objectionable. They should be ruthlessly condemned

wherever they may be found. They are entirely unnecessary, are only excuses for want of proper arrangement, and reasons for delay in getting rid of a difficulty. Then, again, sewers which act as elongated cesspools, and allow of deposit, have muddy filthy bases, and do not show the material of which they are constructed, but have always a coating upon their bottom surface, are objectionable. Sewers must have a proper fall.

These are points, however, more for the engineer than for the doctor; but, when it is proposed by anyone—even the most eminent engineer of the day—to introduce a long sewer into a given district with a fall of less than five feet in a mile, it appears to me that, whatever the velocity that can possibly be attained, there will be a tendency to produce a deposit, and that such an inclination is insufficient and objectionable, unless there is such a volume of sewage as will provide a moving power in addition to the fall, for a large sewer allows a lesser gradient than a small one. In such cases, some artificial means must be used to ensure a sufficient velocity to render the sewer self-cleansing. This object can be attained by temporarily increasing the volume which is passing through them in a given time; this operation is ordinarily called flushing. It will be the duty of the medical adviser to see that such things are neither forgotten nor neglected in arranging any system of sewers. Small sewers will require a greater fall

than large ones; at the same time, the great sewers must always have running through them a sufficient flow of sewage to ensure a thorough "scour," otherwise they will only increase the evils. The velocity in the sewer must be proportionate to its size. The adjustment of velocity to capacity is beyond my province, but it is unfortunately a point which is not always sufficiently considered by engineers; and, whenever foul smells arise from a sewer, something has been omitted, by means of which a deposit has taken place in the bottom of that or some other sewer with which it is in immediate connection. Fresh sewage does not produce smell; smell does not arise until fermentation (which gives rise to gaseous products) has commenced. There must be stagnation, or a condition of sewage in which movement is slow; and slow movement allows of chemical change, with the evolution of gaseous matter. Self-cleansing sewers will not allow this process to take place; if, therefore, there is a smell from a sewer, there is something wrong in its construction, and the engineer who manages or constructed it has been to blame.

Insist, therefore, on getting this evil remedied, as soon as possible, in all cases in which smells continue to arise from any opening communicating with a sewer. The first idea in such a case is to stop up the opening, to cover the hole from whence the smell proceeds, and so prevent any evil from that particular spot. This is a senseless

proceeding. Smells in the open air from sewers are comparatively harmless; that is, compared with sewer air which happens to be discharged into a house. I showed you, in a former lecture, that the power of dealing with such matters out of doors, by the agency of dilution and diffusion, is such as rapidly to render them harmless; but, let them be bottled up, they then become more concentrated and capable of doing much greater executions at other places. Gases will not be kept in the sewer, but will find a way out somewhere—probably into a house in which there is not a tithe of the diffusion, and where there is no ozone to oxidise the offensive matters.

The indications to be derived from a smell at a sewer opening are twofold. First, to enquire whether the sewer is sufficiently ventilated, and then to see that the sewer of deposit is altered in its character, and that it be made self-cleansing. Strike at the root of the evil, instead of merely transferring the mischief to some other place. Sewers require to be freely ventilated, so that an entrance may be provided for fresh air, as well as an exit for the products of change if they arise, as to some extent they will at certain seasons of the year. The equal temperature of sewers (for they always range in this climate between 50 and 55 or 60, and are not liable to the sudden changes which arise out of doors), the constant state of moisture in which the air is kept, and the presence of organic germs and fungi of an aquatic kind,

may so combine that development of sewer gas must take place. The more fresh air, therefore, which is introduced, and the freer the current through the sewer, the less chance there is of concentration and of a resulting evil. The movement of sewage which is always taking place in the sewer; the alteration of temperature and moisture in it, as compared with the outer air, will keep up ventilation if we give it a chance; this we can do, by making the openings into the sewer sufficiently numerous. There should be gratings every 100 yards, at least, in all large sewers, and at even shorter distances if they are of large capacity, and liable to have sudden influx or efflux of sewage.

These are matters which really belong to the engineer, but unfortunately there are many men employed as sanitary engineers who are imperfectly acquainted with the principles of sanitary science, and constantly on the look out for employment, much as a certain class of men are said to get money. These so-called engineers construct sewers which only act as elongated cesspools, certain, in the long run, to do evil to the neighbourhood in which they are constructed. The men I mean are generally employed because they are apparently cheap, but they would really be dear at any price. If there is a smell from a sewer, you may put it down as a certain fact that the construction of that sewer has been faulty, or there is some alteration of condition which renders a

new one a necessity; and the sooner that is done, the better it will be for those who live upon the line of it.

I was instrumental some years since in introducing a proper system of ventilation into our district (Croydon), and the engineer to our Local Board inserted into the ventilating shafts wire baskets containing charcoal. They were useful in those places where the sewers, from having been improperly laid, had become sewers of deposit, for they either deodorised the air which escaped, or kept it in the sewer, so that it was not perceived to the same extent as before. A long-continued observation has, however, shown me that these baskets, however useful as makeshifts for a short period, do more evil than good by interfering with the proper ventilation of the sewer; that a free exit and entrance are better than charcoal air-filters. The proper course, in the case of smell from a sewer, is to alter the condition of the sewer which gives rise to it, and get rid of the deposit which is its cause.

I have not thought it requisite to prove by figures the necessity which exists of removing filth from the neighbourhood of our houses. You may take it for granted that such removal is necessary, otherwise the accumulation will give rise to illness and all that class of zymotic disease to which I have already alluded so frequently. All diseases are rendered more deadly if we keep human excreta near to our dwellings in its

retrocedent state. It must be taken away, and the sooner it is either removed to the outskirts of a town, or mixed with earth in our gardens, the better.

Thirty gallons of water per head per day, good sewers, a good fall and perfect ventilation, with obedience to the canon laws as to sewage and water supply, may render a town perfectly safe, as far as the inhabitants of that particular town are concerned. What, however, is to become of the sewage at the outfall, and how is it to be treated there? In some instances it is cast into the sea at once; in others it finds its way into our rivers, destroying everything — fish, flesh, and vegetable—in its course; in others, it is purified and then discharged into the nearest water-course. I need not detail to you how this condition of things has arisen. The introduction of water-closets has been, like the old-fashioned plan of cesspools under the floors, an evil which is now working its own remedy. The Law Courts first, and then Parliament, declared that one town shall not send its refuse into the borders of another, or even allow it to become a nuisance to one of its own people without compensation being made. The payments on this account have been heavy enough to deter towns from continuing the practice, and a monetary consideration has been more powerful in checking nuisance than the injury to health which was the consequence of such negligence. It has led to experiment after

experiment, until at length there is evidence enough to show that the best course which can be adopted in every instance is to utilise the sewage.

Much mischief has arisen, and great disappointment has been caused, by mistaken notions as to the financial value of town sewage. Ordinary town sewage, and rich London sewage, has been analysed repeatedly. It has been found to contain so much nitrogen as ammonia, so much phosphate and other manurial matters, and calculations have been made to show that this sewage is worth so much a ton; so many tons of sewage were formed in a given time—*ergo*, a certain value was produced. We might just as well purchase sand or auriferous earth in the same deceptive manner, because it contained so many grains of gold, without making any reference to the difficulties of getting it out, or to the cost of separating it. Agriculturists even expected to buy the sewage at so much per ton, with the certainty of realising a profit. As well might the Directors of the Bank of England give £3 17s. 10d. for a ton of quartz rock in an African gold-field, because it was estimated to contain an ounce of gold.

In the abstract, the value is there, but the difficulty is to get it into contact with growing vegetation, by which it can be utilised. In some cases the fœces are allowed to go into the sewers with the urine; in others they are kept out. But I may mention that, commercially, the urine of a healthy individual has more valuable manurial

matter in it than the fœces of the same person. This fact has an important bearing upon the utilisation of sewage, and proves that, even if in a given town earth-closets are in use, by means of which the solids are kept out of the sewers, it is still necessary to provide for the utilisation of the sewage before it is discharged into an ordinary water-course. To estimate the value of sewage, we take the quantities which are passed in a given time—say one year. We are accustomed to consider the produce of the nitrogen as averaging 12½ to 13 lbs. per head, and this calculation has been proved to be correct by experiment. It has been made out that the money value of this excreta amounts to about 8s. 6d. per year; that of the urine being more than five times that of the fœces, weight for weight. It might be supposed that the fœces are more valuable, but this is not the case. I have not yet been able to prove that the financial value of sewage is as great as 8s. 6d., on any large scale; but sufficient evidence has been obtained in isolated cases to show that a certain number of tons of liquid sewage, applied to so many acres of land, enabled that land to grow crops which have produced a return equal to 8s. 6d. per individual. But, when we apply this calculation to the whole of a given farm, we do not get the figures to correspond. In the case of the farm in which I am most interested, the sewage of 46,000 persons is utilised on 466 acres of land, without any allowance being made for the value of manure from animals,

which goes into the same channel, as does also the refuse of manufactures. We ought, on the foregoing basis, to realise nearly £20,000 from the farm. We are unable to get back half that sum at present, but, from personal experience, I am satisfied that it would be quite possible to realise 5s. per head, and that is quite high enough to assess as the possible value of human manure; but to obtain this return Corporations must be prepared to spend something considerable. Like gold mining, the pure gold is not to be obtained without a very great expenditure. The amount really produced from the Beddington Farm during the past two years has been a little more than 3s. per head of the whole population, and this return has been obtained without any allowance having been made for the capital invested in and upon the farm; and hence capital charges are made to appear as current expenses.

I have already mentioned that the great principle of sewage utilisation is, that it shall be used fresh. Any attempt to keep it about our premises, to collect it in quantity and then to dispose of it, is attended with a rapid loss of value. Water-carriage by sewers enables us to so utilise it if we can find the means; and I may at once tell you that there is no known way by which such utilisation may be effected so perfectly as by sewage irrigation. I shall detail to you presently other plans by which sewage may be utilised, and what is called defæcated, so as to render it comparatively innocuous.

If it is possible to get land for the purpose, and especially if that land can be irrigated by gravitation—that is, by the sewage flowing directly on to it without the expense and difficulty which arises from having to pump it to a higher level—utilisation by sewage irrigation is the plan which alone effects every object that the sanitarian has in view. At the same time, I think it would be highly objectionable to concentrate upon one point all the sewage of a great city like London, or to bring it into one district. There is no reason why it should not be taken in detail and distributed, so as to lessen the evils which may spring from the non-utilisation of sewage because of its excessive quantity at a given spot. We will suppose, however, that a town of 50,000 inhabitants has all the requirements that I have mentioned—that the outfall of the sewer is at its lowest point; in round numbers, the sewage conveyed on to the land ought to be worth £5,000 a year, after deducting the cost of labour and material in its utilisation. Hitherto this amount has not been realised as a clear profit, and, until it has been, it is useless to talk of the financial value of sewage.

I advise you, therefore, in any plans you may be interested in for the disposal of sewage, not to calculate upon a handsome financial return. The value is there, but it is mixed up with so much dross that it absorbs all the profits in the cost of extracting it, mainly for this reason—that the growth of a town adds a fictitious value to the

land around it, and it is impossible now to obtain a farm in a suburban district at anything like a fair value. In ordinary cases land is let to agriculturists, and sold at satisfactory and reasonable prices; but the moment it is wanted for State purposes—that is, for sewage utilisation—the public spirit of its owner evaporates, and he is bent upon transferring the total value which the sewage contains into his own pocket. If, therefore, a town requires 500 acres for utilisation of the sewage of 50,000 people, the owners of the land which is suitable for the purpose take care to demand for it a sum which not only represents its agricultural value, but also the amount which it will be capable of extracting from the sewage itself. Thus it happens that the first rental which has to be paid for the land includes all the profit which can be got out of the sewage. This is a penalty which towns must pay—a blackmail which landowners levy upon the towns for the invasion of their property. If we put a round sum as the agricultural value of land at £2 per acre, we must add to this its utilising power, which will be from £3 to £7 or £8 extra, according to its vicinity to the town in question; the nearer it is the fresher will be the sewage, and consequently the greater its value.

Thus, the sewage of 50,000 being valued at £5,000 a year, that sum has actually to be paid by the town for the privilege of turning it to account. The town must then defray the cost of utilisa-

tion out of the rates. If the Local Authorities have been fortunate enough to secure land at a lower price than that I have mentioned, so much the better for the pockets of the ratepayers; but you may take it as tolerably certain that it will be many years before much return will be made to towns for the sewage they produce, no matter in what way it may be utilised. Indeed, it is not the present return of £ s. d. which must be thought of; it is Health, and if sewage farms will confer that blessing without entailing a heavy burthen upon the ratepayers, they ought to be thoroughly well content.

From what I have said, therefore, you will not expect that sewage irrigation is a source of wealth to a given town. It is a mine of wealth to the landowner whose property is favourable for utilisation; like a coal-field, the owner gets the best pull. The worker in the mine is liable to various accidents, which often deprive him of his just share of profit, but the proprietor does not suffer. So it is with a sewage farm; and, in consequence of the heavy rental which has to be paid for land, many substitutes have been proposed. I will mention them in due course; but as I look upon the fact that, if ten thousand sewage farms were established in the kingdom, each of which had been purchased by an individual landowner, we should have ten thousand men enriched by the process, the £5,000,000 a year which, according to my calculation, represents the money value

of the sewage of our land, would go into the pockets of landed proprietors, and be afterwards spent among the people, instead of going as it now does, in a great measure, to waste, and in its waste does so much to destroy life, and add to the burthens which oppress the people. If, therefore, the ratepayer has to pay a small sum towards its utilisation, he would lose nothing, whilst the country generally would be an immense gainer by improved health—ten thousand men who were only moderately well off would be secured a handsome income for themselves and their families.

As good citizens, therefore, anxious to promote the interests of your own country, I impress upon you the duty of urgently directing the attention of your constituents to the subject of irrigation. There are two other considerations connected with this matter which have a bearing upon its political economy. One acre of land, which under ordinary agricultural work will only raise food, at most, for one bullock, would, under sewage irrigation, produce four times that amount. The producing power of a given area of land is increased fourfold, and, with that producing power, employment is provided for a larger number of hands, and entails a greater expenditure for wages. Indeed, this is one of the advantages which have not always been thought of, in dealing with the financial aspects of sewage irrigation, that, if you get half-a-dozen crops off the same land every year, instead of one or two, you must employ

additional labour for the purpose of saving these crops, and preparing the land for the next cutting. This involves a considerable expenditure for wages, which has to be taken into account, and paid for out of produce. At the same time, it must be borne in mind that such outlay forms really an addition to the national wealth of the country.

A town of 50,000 persons should have at command 500 acres of land—that is, one acre for each 100 persons. If the water supply should equal 30 gallons per day, this will produce 1,500,000 gallons of sewage to be dealt with, irrespective of rainfall. In our part of the country the reception of rainfall into sewers will, on the average, make a daily addition of 1-5th more—that is, 6 gallons per head. Should it exceed this quantity, there will be more surface water admitted into the sewers than the exigencies of legitimate sewering will require, for the quantity should depend upon the houses, paved yards, and streets, rather than the area. Even if the quantity of surface water should be doubled, and be equal in amount to that of sewage—a condition not likely to arise, except in some of the wet districts of England—we have this result, that each acre has to take 3,000 gallons of sewage every day, with the rainfall in addition. At Beddington, we have to deal with about 2,500,000 gallons daily; this is distributed on about 45 acres, more or less. It gives 277½ tons to the acre; that is the sewage of

about 1,200 persons for each day, and it equals a rainfall of less than 3 inches in 24 hours. At the same farm, we pass on to the land 10,000 tons of sewage to each acre, which gives a daily average of 28 tons, equal in amount to a rainfall of about 100 cubic inches in the year. There are some places in England that have this amount of rainfall naturally, and are not considered unhealthy, but the contrary.

I will state an extreme case. Let the average daily supply at Beddington be 3,000,000 gallons, and the average of land under irrigation as 365 acres. I take this number for the sake of ease in calculation. Each acre will then have 3,000,000 gallons in the year, equal to 12,500 tons of sewage, or the sewage of 123 persons. If the whole sewage were passed on to the acre at once, it would cover it to a depth of 11½ feet, equivalent to a rainfall of 138 inches in 365 days. It is distributed like rainfall at irregular intervals, and many places in Great Britain and Ireland exceed that quantity. Borrowdale has 165 inches; Leathwaite, 140; Langdale, 111; and the beautiful Vale of Ambleside, 88. Notwithstanding this heavy rainfall, the land absorbs it, and becomes dry in a few hours, and its fertility is most marked.

It is only lands flooded from the mountain districts, and which in consequence of obstructions cannot clear themselves below the point of outfall, that require to be under-drained. It has been

remarked by the late J. F. Miller, in the "Philosophical Transactions," that, notwithstanding the heavy rainfall, there are not those extremes of heat and cold that are met with in the more southern counties of England. The mean temperature at Chiswick is much the same as in the lake districts of England, but the extremes are much greater at the former place than in the latter. The caloric evolved in a sensible form by the condensation of enormous volumes of vapour tends greatly to modify the climate of the wet districts of England and Ireland. This modification will be introduced in a smaller degree by the action of sewage farms, when they are generally established in those districts which have a lower rainfall. They will help to modify the extremes of heat and cold, and bring the temperature of the district nearer to a mean than it is now. This will be in a small degree, it is true, but it will be in the right direction; and, should it reach but half a degree only, it could not possibly do harm, whilst the disadvantages of rainy weather would not be so strongly felt.

I am not about to give you a lecture upon sewage farming, because I should want half-a dozen hours to do it satisfactorily; but I must deal with the question of under-drainage, because that is one which you, as medical men, will be called upon to consider. It is said by scientific farmers and sanitary engineers that it is absolutely necessary for the farm to be deeply drained,

and that no farm should be allowed to continue without such draining. I am sorry to be almost alone in opposing this view, but I am satisfied that it is a wrong one. In choosing land for the purposes of sewage irrigation, it is necessary to take that land which will drain itself without troubling the engineers. There is no objection to take land which is liable to be flooded, if after flooding the ground dries again—that is, if the natural drainage is sufficient for the purpose intended; and if the substratum of the farm rests upon an impervious bed, so that the sewage cannot sink to any great depth, so much the better. I have an objection to drains put in at a depth of six feet or so; because I find, by experience, that these drains, after a time, convey the effluent away before it has been completely purified. Water collected at the outfall of a land drain is often found much more impure than it ought to be. The tendency, also, of deep drainage is to allow the sewage to soak at once into the soil, down to the level of the drain-pipes. This gives rise to a serious disadvantage, by causing a difficulty in the abstraction of all nitrogenous matter by vegetation. The great principle to be kept in view is, first, that the sewage should be applied fresh to the soil; secondly, that it be kept as near to the surface as possible, so that it may be brought at once in contact with the spongioles of the growing crop, and be altered in its chemical character before it can get into the underground

water. The sewage, as delivered, contains abundance of carbonic acid and no free oxygen. In this state the vibrios, or fungus germ, upon which I believe that the production of certain zymotic diseases depend, are able to develop most luxuriantly, and to produce evil if that effluent should be used in its raw state as a potable water. Keep the sewage, therefore, on the surface of the soil, so that oxygen may get in contact with it, and the rootlets may absorb it rapidly, and so that no disease germs may be able to fructify in the deep soil, where neither light, air, nor oxygen is available.

If it should be impossible to grow crops on the land for want of deep drainage, on account of the land being unable to drain itself, then subsoil drains must be laid down—that is, if no more suitable land can be obtained. The drains should be so arranged as to have pea-stocks put down before the sewage is put on, and should be filled with subsoil water, when the sewage is applied. The effluent should not go from the outfall until after irrigation by sewage has ceased. Then, if the pea-stocks are raised, and the land dried, the deep drainage will render the land available for the purpose of purification; but this deep drainage should not be going on during the time that sewage is running over the land.

In a subsequent paper will be found a practical exposition of the power of soil, air, and vegetation to purify sewage. The remarks I

made in a former lecture upon the effects of filtration in purifying water bear upon the subject. It is now thoroughly established that intermittent downward filtration, as it has been styled by Dr. Frankland, is capable of dealing with sewage, and rendering the effluent water comparatively, if not perfectly pure; but to effect this object the action of the filter must be intermittent in reality, the power to oxidise must be constantly renewed, and air must be allowed to enter the interstices of the soil, so that those elements of life which find their opportunity for evil, in the absence of oxygen, may not have that occasion afforded them on the farm. But the principle of intermittent downward filtration is the secondary point in the working of a sewage farm. It changes organic matter into nitrates and nitrites, which are important salts, as far as vegetation is concerned; but there is no necessity to reduce them to the state of mineral salts before they are utilised. Vegetable life is able to deal with albumen and other organic matters in sewage at once, without it being necessary to reduce them to the inorganic state. That reduction would be a waste of power, which Nature is never guilty of in her laboratory. The constituents of sewage are digested by plant-life at once, if it can get access to them. Nitrates and nitrites are only formed when it is requisite to store the material for another time. The first thing, therefore, and the greatest power on a sewage farm, is vegetable

growth; and, the greater the producing power in this direction, the more certain it is that the soil is effecting its legitimate work of purifying the sewage. The more this work goes on, the greater will be the effect of that purification on the air of the district by the discharge into it of large quantities of oxygen in its more potent state. I know that I am stating a view of the case which is opposed to that of the great agricultural chemist, Liebig, but my experience has been gained upon a sewage farm itself, and not in the laboratory; and, knowing something of Nature's works, I cannot witness that extraordinary action which I see going on upon a sewage farm, when the sewage is first applied to a field of rye-grass, without being at once struck with the magnetic or vital power of the rootlets to detain and absorb all organic germs which exist in the sewage itself, and to give a very decided answer in the negative to a question that is sometimes asked—Whether disease germs will not escape from the clutches of vegetable matter, and become active again in the effluent stream? But it is requisite that the germs in question shall not be distributed in excess of the power of the plant to deal with them, and this is a matter of detail and practical experience.

If a railway is to carry passengers, carriages must be provided; but to argue that a railway cannot carry passengers because carriages are not supplied for the purpose, and therefore rail-

ways are of no use, would be as sensible as to decry sewage farms because sewage is put on them in excess of the power of vegetable matter to deal with it. It is also said that vegetables themselves do not decompose the material with which they are fed, and that disease germs may remain in the vascular tissue of the plant, and thus be transferred to human beings. The possibility of this result is held up as a reason for discouraging sewage farming. The condition is possible, since it is no uncommon thing for rhubarb and other succulent vegetables to have an odour arising from the manure with which they have been treated. I doubt whether such odours really have any affinity to disease germs, but their presence is an indication of improper gardening, and not of the inability of vegetation to deal with manure. It is no more a sound argument against sewage farming than it would be to assert that steam-power is not a thing to be encouraged, because it may destroy the engines if the safety-valves are neglected. A disease germ may escape destruction if it is stored away from light and air; but it cannot escape destruction if it be brought into contract with oxygen, just as it is set free from its combination with other matters in the vascular tissue or intercellular passages of vegetable growth. The point to be attained is to regulate the supply so that it shall not be in excess of the power of the plant, in which case digestion is ensured,

and the destruction of the germ is effected to a certainty.

If, therefore, it be possible for a Local Authority to deal with the sewage of a water-closet town by irrigation, that method ought to be adopted. The farm with which I am connected has given a striking proof of its power to deal with disease germs, for during the past year the excreta of more than 1,000 cases of typhoid fever have been dealt with. The effluent has passed from the land into the Wandle; numbers of people drank the water of that river, but no typhoid or any other zymotic disease has shown itself along the valley of that stream. There may be some cases, as also in other parts of Greater London; but the Registrar General's barometer gives no sign of any increased evil, and it is a certain fact that the farm has arrested and destroyed the whole of the potent matter of more than 1,000 cases.

If it is not possible to deal with sewage by irrigation, the next best way to treat it is to change it into inoffensive salts. This is effected by intermittent downward filtration. Mr. Baily Denton is the engineer who has turned this process to the best account. He has arranged a series of filters on a large scale, by means of which the sewage of 2,000 persons is dealt with for a limited period on one acre of land.

The filters consist of ordinary shingle, burnt clay, or gravel, and must be effectively constructed, so

that there are two feet, more or less, of proper soil on the surface. This surface is cultivated in the ordinary way, root crops and cabbages being grown upon ridges, whilst the furrows are utilised by running sewage into them. Each plot is used for six hours at a time. The under-drains are laid at depths varying from 6 to 10 feet, according to the fall, and the effluent passes away sufficiently pure to be allowed to flow into a water-course; whilst water which flows off after the filter has been in operation for a short time is comparatively, if not perfectly, pure. After a time the salts appear, and then that which is regarded as evidence of previous sewage contamination becomes manifest, for ammonia is given off. The filtration should then be stopped, and another filter-bed used while the first one has a rest allowed, so that the interstices may be again charged with oxygen, and the power of the filter restored. It would be possible for a town of 50,000 persons to have their sewage purified by about 20 acres of land, if 40 acres were laid out, and vegetable matter, as rye-grass, grown freely on the surface of half of it, on alternate years, whilst the other half had ridge cultivation only; and the evil of waste would be reduced to a minimum. Such an arrangement would not be doing the State so much service as sewage irrigation proper does, and it involves also the loss which must arise to the country from the capital sunk in forming filtration areas. No large annual returns could be obtained, and no landowners will be

enriched by the process, as is the case in extended irrigation.

But there are places where it is not possible to employ either of the above methods, and it then becomes necessary to provide other means whereby the sewage of a district may be disposed of so as to avoid nuisance. In such instances, especially in small villages and isolated nests of houses, sewers are out of place; nevertheless, it becomes necessary to provide for the utilisation of the sewage. In any case, cesspools are not to be tolerated, and a plan may be adopted of collecting the solids in proper tubs; whilst the slops and wash water may be allowed to pass away, with less danger, into some water-course which is not used for drinking purposes, or be passed over land. You will gather a proper way for doing this by following up our experiments as shown in the hamlet of Waddon. I give it you as submitted in May last to the Sewage Conference of the Society of Arts, and published in the Journal of the Society. The account sets out some of the difficulties a Local Authority may have to contend with when small owners are bent upon turning a swampy area into building plots. The following is a reprint of the paper :—

THE PRACTICAL EXPERIENCE OF THE DRY SYSTEM, SHOWN BY THE USE OF MOSER'S CLOSETS, IN A SMALL DISTRICT, FOR TWO AND A QUARTER YEARS.

It is well known that Croydon is drained in the ordinary way; that is, more or less imperfectly, but there are small areas which are not sewered at all. Among these is the hamlet of Waddon; it lies between Beddington and the south-western part of the parish of Croydon. It is a district in which the water-line is constantly changing, according to the requirements of the miller who works the water-mill which has existed, from time immemorial, at the confluence of the several streams giving rise to the River Wandle. The occupiers of some of the fields near to the hamlet have also the right to dam up the Wandle, and use it as a sheep-wash, and also the right to irrigate the pastures themselves. The result of the maintenance of these rights is, that the subsoil is generally water-logged, as the water remains within a few inches of the surface of the ground. Notwithstanding this state of things, a number of cottages were built on a part of the land close to the left bank of the principal stream of the Wandle. When the plans were first deposited by the speculators who proposed to erect these houses, there was no law by which they could be compelled to provide

a dry basement. Application was made by the builders to the Local Authority to sewer that district at the public expense, but the Local Board declined to do this except at the cost of the owners. It was contended by the writer that the ratepayers of the parish ought not to be called upon to convert a swamp into building land, for the benefit of speculators. Nevertheless, the houses were built, and immediately occupied by a swarm of poor. The result, which was predicted when the plans were deposited with the Local Board, soon came to pass. The inhabitants suffered continually from the effects of enthetic disease. Scarlatina, diphtheria, and fever were continually present. The neighbours began to complain, and many deaths occurred. The stench from the continually overflowing cesspools was plainly perceptible in the public road, and great pressure was brought to bear upon the Local Authority to compel them to sewer the district, at an expenes almost equal to the value of the cottages themselves. But it appeared to me that to put sewers into such a district would be a sanitary mistake ; at least one-half of the time they would be water-logged, and be the means of retaining mischief in close proximity to the houses, instead of conveying it away. It was necessary, before sewering the district, that the water-line should be permanently lowered, and the owners should give up the right to flood the neighbourhood, and thereby make the land fit for building

purposes, before the Local Authority should be called upon to provide sewers. There was also another consideration in the case. The sewage from these cottages would have to be conveyed to Beddington Sewage Farm. There would then be a 12-inch sewer, constantly discharging subsoil water instead of sewage upon a farm which already receives more subsoil water than it is entitled to. The owners refused to do their duty, and it was left to the Sanitary Committee of the Croydon Local Board of Health to devise a remedy for the insanitary state of the hamlet, which the law had tacitly allowed to grow up under our noses, and in spite of our protests. The year 1874 was a very fatal one to the inhabitants of the cottages; the owners did not—indeed, they could not—empty the cesspools which had been constructed, and it was evident that something must be done. The property had changed hands, and the new owners were willing to do what the Sanitary Committee recommended. I had been much struck with the simplicity and cheapness of Moser's closets, as exhibited at the Social Science Congress at Glasgow, in 1874; and ultimately twenty closets were erected by Mr. Moser, at a cost to the owners of something under £3 per closet. They were completed December 24th, 1874. The cottages are in a block close to the road, and about one-third of a mile from the outfall sewer, near to which the town refuse of the Croydon

district is conveyed. It was agreed with the owners that they should erect the closets, but that the Croydon Local Board should collect the refuse, and supply the hoppers with dry ashes, and the pails with sawdust, as often as should be necessary. The whole of the arrangements were carried out, and have since been superintended by Mr. Mitchell, the Sanitary Inspector of the Croydon Local Board of Health, and I learn from him the following results: — He states that, whereas serious illness always prevailed in those houses before the erection of the closets, there has been very little since, and scarcely any of that class of disease which formerly visited them; that the houses, instead of being pest-houses to the neighbourhood, are now perfectly healthy. It is also stated, in Dr. Buchanan's report upon the epidemic of fever which visited Croydon in 1875, that these cottages at Waddon altogether escaped. Mr. Mitchell also states, in a written report—

"That he had had no complaints in writing at all. That there were a few verbal complaints at first, in consequence of the trouble the occupiers were put to, whilst the workmen were about; but that they soon settled down, and that when they got used to the closets they expressed great pleasure at the change, stating that they were now free from the offensive smells to which they had been previously subjected, and that they suffered no inconvenience, except when the men

were late in removing and changing the contents of the tubs."

It ought to be stated that frantic efforts were made to rouse the people against the use of the closets, and to compel the Local Authority to sewer the district, and that a strong antagonistic feeling had to be contended against when they were first introduced.

The closet consists of a hopper at the back, large enough to receive a week's supply of earth, sawdust, or ashes. By means of an exceedingly simple arrangement, the hopper discharges the ashes or earth upon the solid fæces, as the user rises from the closet. The pail is placed beneath the seat. It consists of half a petroleum cask, well bound, with an upright diaphragm, which separates the anterior part of the pail from the posterior, the former being arranged to receive the urine, and is charged with sawdust. The pails are changed weekly, between five and six in the morning. The duty of collection is performed by one of the dustmen, who collects town refuse during the later hours of the day. The total cost for two years and a quarter—that is, to the end of March, 1877—has been as follows:—

	£	s.	d.
Wages of man and boy	47	4	6
Horse and cart (use of)	14	12	6
Sawdust and ashes	8	9	0
Total cost for 118 weeks' collection	70	5	6

That is, £70 5s. 6d. appears in the accounts of the Local Board as the cost which the ratepayers have incurred during the last two and a half years, in collecting and replacing the pails at Waddon. Against this sum there is a set-off, in the value of the material collected. This is mixed with other refuse at the filtering-house, and is sold, with that refuse, to market gardeners at 2s. 6d. a yard. It is probably worth rather more than that, but, not having been kept separate, its practical value is not known. About a yard and a half is collected every week, which reduces the actual cost by 3s. 9d., or to 8s. 3d. per week instead of 12s., which would appear to be the cost according to the published accounts. Twenty closets were erected in 1874, and two have been added since; thus 22 houses, occupied by 122 persons, have been provided for, the cost being £1 8s. 5d. per house, or 5s. 1½d. per person per annum; or, if we allow the value of the produce to be deducted, the cost is reduced to 3s. 6¼d. per person, or to a trifle under £1 per house per annum. Of course, the experience of a small district puts the expense at an outside amount, and if, instead of 22 houses, there had been 220, the expense would be reduced by one-half. I am inclined to think that 10s. per house would amply cover the cost of the collection of excreta in a country village of 200 houses; and, if the average rateable value of the houses in such a village is put at £15, it would entail a

rate of 9d. in the pound to provide for the removal of excreta by a dry earth plan. At the same time, there would be no debt incurred, and no mortgage of the rates necessary. I simply submit these facts for the consideration of the Conference.

It may be asked in what way the slops are provided for at the houses to which I have referred. When the closets were fixed, the cesspools were pumped out and the concrete broken down; the communications between the closet and drain broken off; the waste-pipes from the sinks were made to discharge upon a trapped grating in the yard, which led by a drain into the old cesspool. From the cesspool a filtering-bed of loose stones and gravel, in a trench from where the drain-pipes had been taken up, was provided, and this filtering-bed led off to the River Wandle. Whenever the level of the water in the bed of the Wandle is below the level of this trench, it draws off into the Wandle without leaving the least trace of defilement or pollution. When the bed of the Wandle is full, the subsoil is necessarily filled with an impure water. If the Wandle was never dammed up, there would be no difficulty whatever on the score of the slop water. In the case in point, and in most cases, if one of Field's flush-tanks could be used, I see no reason whatever to suppose that any evil would arise at all, the only necessity being that houses should not be allowed to be erected on land which is water-logged.

For small blocks of houses at a long distance from any system of sewers, or in thinly-peopled districts, I can confidently recommend some such plan as that of Moser's, as amply sufficient to prevent defilement of subsoil by sewage, and enough to provide for the removal of nuisance. But such arrangements must be under the control of a Local Authority, who must see that the proper removals are made at proper times; and the authority must be alone responsible for its proper management.

THE POWER OF SOIL, AIR, AND VEGETATION TO PURIFY SEWAGE.*

Soil, Air, and Vegetation—Power of Purifying Sewage—Filtration through Soil—Varying Power of Soil—Oxidation—Physiological Errors concerning Plant Life—Carnivorous Nature of Rye Grass—Drosera Dionæa—Dr. B. Sanderson's and Dr. Hooker's Observations—Destruction of Living Germs by Vegetation—Pettenkofer's Theory—Deodorising does not Necessarily mean Destruction—Experiments on the Powers of Rye Grass—Assimilation of Albuminoid Ammonia—Capacity of Plants to deal with—Parliamentary Evidence on Sewage Farms—Effluent of the Croydon Sewage Farm—Health Statistics of the District.

I HAVE taken the subject of the practical power of soil, air, and vegetation to purify the sewage of water-closet towns for our consideration, as distinguished from that which may be called the theoretical view of the question, because the actual power of agriculture to purify sewage is not now denied by any reasonable student of Nature. It is acknowledged that the filtration of sewage, however concentrated or however diluted, through common soil will effectually remove all the objectionable matter which is contained in the

* A Paper read before the Society of Medical Officers of Health, 1875. Rewritten, with additions, August, 1877.

water—that is, filtration will remove all organic matter from the water, and allow it to pass away perfectly purified, provided the filtration is continued long enough, that the filter is renewed often enough, and the thickness of filtering material be fairly adequate for the purpose. This is now an acknowledged fact, and it is sufficiently established by the aid of experience, as well as of chemical analysis, for me to take it as an axiom, without being called upon to demonstrate its truth. The theory of sewage purification by soil is the foundation of continuous sewage irrigation, but the property of soil is not everlasting ; its power to extract organic matter has a limit, and, if the action of the filter be continued after that limit has been reached, there is a cessation of purification, and nuisance with its contingencies are inevitable. The water which passes through the filter may be absolutely less pure than before filtration was effected. The result of this action was shown in the year 1874, at the Royal Patriotic Schools, at Wandsworth. It was proved by chemical analysis that the water supplied to the children in the girls' school was less pure after filtration than before ; that it contained more nitrogen and phosphoric acid than was present in the water before it passed into the filter. An examination of the filter itself easily explained this anomaly. The filter had become foul by continuous use ; the matter taken out by the filter had become sufficient to set up a diffu-

sive action, and by putrefactive changes to pollute the water in its passage through the filter, and is a marked and practical proof of the danger of filters.

Soils vary in their power to extract organic matter, some being more competent than others to effect the object in view; some are powerful enough to purify water if it passes through a foot or two of material, as is the case for a short time in the ordinary water filter; others do comparatively little, and soon lose their virtue by saturation. I am not, however, about to inflict upon you a discourse upon the capacities of soils, but simply to ask you to concede the point, and then conduct you to the second term of my propositions—viz., the power of air to assist the process, for soil alone has a power of attraction which is limited to a small compass. If a filter is continuous in its operation it soon fails; but if its action is intermittent, if the soil in use is allowed to run dry and the interstices which naturally exist in it, and which, whilst in action, are filled with water—if those interstices are allowed to become re-charged with air, the power of the filter is restored and purification is again effected. There is an oxidisation of the organic matters contained in the interstices of the filter; the arrested organic matters become mineral organic salts, and pass away into the water as nitrates and nitrites, when the filter is used, and afford evidence of a so-called previous sewage contamination. In themselves the salts

are harmless in the quantities in which they are usually found in filtered water. Oxidation is the principle in operation in the plan, which is called intermittent downward filtration. The organic elements in the sewage, which are dangerous in their recent form, are changed into harmless salts, and are comparatively lost to agriculture. This tends in the long run to produce an imperial bankruptcy, by casting away a valuable matter which has to be recouped to us as a nation by purchases from other countries. Still, intermittent downward filtration effects a partial object, and can be made applicable for the purpose of purifying sewage in those places where it is found impossible to bring to bear upon the matter the third term of my proposition, and which is the most powerful agent of the three in the series, viz., vegetation. A filter requires rest to allow of the reintroduction of oxygen for the purposes of oxidation ; but the true principle of sewage utilisation is, for that oxidation not to take place at all, but that the organic matter which is arrested by the soil should be taken up into its natural storehouse, made to revert into the formed material of plant-life at once—rather than to change into a chemical salt which has to be decomposed again by the vital power of the plant, re-absorbed into its juices, and so brought back to organic life by a roundabout process, instead of that direct one which Nature provides in her agricultural laboratory.

It has been supposed by physiologists that it is in all cases necessary for such a change in the character of organic matter to take place before it can be assimilated by plant-life. It has been thought that the effect of manure when applied to land has to be obtained after the stage which has been called previous sewage contamination has been reached—viz., that all organic matter is changed into ammonia, nitrates, and nitrites, or has entered into chemical combination with the earthy bases, sulphur and phosphorus, which are more or less found in manure of every kind. In the year of 1868 I showed that this was not so; that, at any rate, as regards rye-grass, that plant may be called carnivorous in its tastes, and that the rootlets of a young crop of rye-grass seize upon the organic elements which are contained in sewage, bring them into immediate contact with the extremities of the spongioles of the plant, and that an actual digestion of the animal matter takes place without any reduction to organic salts coming to pass, such as that which really does arise in the process of filtration. My observations were thought to be scarcely worth consideration. It was said that the food of plants must be reduced to an inorganic state before plant-life can be nourished by it; that this was an axiom of vegetable physiology, and any different opinion upon the subject was not worth a thought. I am now emboldened, however, to bring up the matter for the consideration of "Medical Officers of

Health," for, since my paper was read at the meeting of the Social Science Association at Bristol, Dr. Burdon Sanderson has published some observations which indirectly bear upon this subject. He demonstrated that, when a leaf of the *Drosera Dionæa* contracted in consequence of its contact with living matter, the effects produced were precisely similar to those which occurred when muscle contracted. He considers that the act of contraction in sensitive plants corresponds in its conditions with the active contraction in the muscular tissue of animals, an electric current being produced in both cases.

Dr. Hooker, of the Royal Gardens at Kew, has also followed out these observations of Dr. Sanderson. He detailed at the meeting of the British Association at Belfast, in August, 1874, some of his deductions. He finds it quite possible for plants apparently to invert the order of Nature, and to draw a part of their nutriment from the animal kingdom, which, he says, "it was oftener held to be the function of the vegetable kingdom to sustain."

That "plants can and do assimilate animal matter without that matter being first resolved into its ultimate elements."

This is precisely the sum and substance of my own observations upon the power of rye-grass to digest animal matter. The protoplasm of rye-grass, as existing in the minute fibrillæ or spongioles of the root, can avail itself of animal matter

for its support without that matter having first to undergo decomposition. The extreme end of the rootlet—the rootcap, as it is called by some writers—consists of cells, which, after the exercise of their function, become detached from the proper cell-tissue of the spongiole, and which have been actually engaged in this process of digestion.

While they are in actual contact, and are a part of the plant, they attract the organic elements that exist in manure in a manner what appears to me to be similar to that which is seen in the process of cloth dyeing, when certain colours are discharged by the affinity which some textures have for certain salts. The vegetable cells having appropriated these organic matters to themselves, they assimilate the contained nitrogenous matter, pass it on into the cellular or vascular tissue of the root, and become themselves filled with either carbonic acid or oxygen; the act of digestion is thus performed, the gases then pass upwards, and their duty is done. They become excretions as far as the plant itself is concerned, and are resolved into their original elements, and washed away by fresh sewage. Manure which has had an animal origin, especially when derived from creatures which are carnivorous or omnivorous, consists of two distinct classes of matter: first, that which is dead, so to speak—that in which all germ vitality has been destroyed, and which must perforce revert to such inanimate compounds as the chemist can

produce in his laboratory, and is absorbed by vegetation in that state; and, secondly, that which still contains germs or granules in which there is a dormant kind of vitality capable of being roused into active life, which may be called, after Dr. Beales' formula, "living matter." This matter requires a continuous heat often above 212° to destroy its active principle, and, when protected by certain kinds of envelopes, may be boiled for a few minutes without loss of life. These germs are able for short periods to resist the action of disinfectants, and are the granules of matter which, if admitted into the economy of the human body, can either reproduce themselves or else bring about some diseased state of the system. The great principle in the utilisation of sewage, from the preventive point of view, is that, if these granules of vital matter are brought into contact with the extremities of the spongioles of plant-life, their character is at once destroyed, the nitrogenous matter of which they are composed is assimilated by the plant, oxygen or carbonic acid is evolved, and neither vitally nor chemically do they remain the same as before they have been acted on by the spongioles of the plant. An electric action is excited precisely similar to that which is shown by Dr. B. Sanderson to happen when the *Drosera* feeds upon the animal which is unfortunate enough to be embraced in its marvellous clutches.

Mr. Darwin is of opinion that the *Drosera*

Dionæa assimilates its food and digests its captives much in the same manner as does the human stomach. The inference may be easily drawn that, if the *Drosera* can do this, the vital power which exists in the protoplasm of the fibrillæ of the rootlets of rye-grass can do the same. These fibrillæ are seen in a state of marvellous activity in a field of rye-grass in which the plant is approaching the time for flowering. If the observer watches a field to which sewage has not been applied for three or four days, he will notice a tangled mass of rootlets covered with hairs, and when seen under a magnifying-glass, just as a stream of sewage reaches them, he will see them excited into a state of wonderful activity. They open out, as it were, to the water just as sea-anemones do to the advancing tide—they expand their fibrillæ, and seem to search for food. I make this as a simile, not that I mean the act is the same. I have not been able to see the actual process of absorption, because, immediately the water touches the plant, the hair-like fibrillæ are taken out of sight; but there is a perceptible movement, and a rapid rise of liquid takes place in the parenchyma of the plant itself, which liquid is not sewage. I contend that the principle of utilisation to be followed out for the entire removal of the dangerous matter in sewage is the growth of vegetable produce by means of that sewage. If it be otherwise treated, it renders possible the origin of enthetic diseases

among those exposed to the action of the material used; for by no other means, except chemical disorganisation or by fire, can the germs of disease be reached and extension certainly prevented.

A very serious question is often asked, and sometimes answered in the negative—Will earth destroy the germs or granules of disease? Will such germs escape from the clutches of vegetable matter in earth, and become again active if passed into a water-course or mixed with food in any way?

Pettenkofer has raised this question, and put forth the idea that ordure, mixed with earth, may be deprived of its noxious smell; but that the germs of disease may still remain. Thus, he asserts that the excreta of cholera patients may not be destroyed if they are mixed with earth, but may remain dormant, ready to develop into activity whenever they are placed in circumstances favourable to their re-appearance. Supposing that such earth, containing ordure in excess, should become mixed with water, and that this water should carry away the germs of disease into a supply used for potable purposes, the disease would be reproduced by those germs or granules, even although they had been previously mixed with vegetable matter in earth. If this be correct, and there is every reason to believe that it is, it shows that the earth-closet plan is not free from a danger which cannot properly belong to sewage irrigation, for the roots

of the plants will infallibly extract every particle of matter of organic origin which has nitrogen in its composition, and which passes within reach of a living vegetable rootlet. Not a single granule capable of reproducing disease can reach the effluent stream if the fields are properly managed, and care be taken to bring every portion of the sewage into contact with growing crops, or with land ready for the growth of new plant-life, the land not being already super-saturated with sewage elements. It is not the deodorising, disinfecting, or re-arranged property of earth which is required so much as the selecting power of the plant-roots. We have no occasion to solve the important problem put by Pettenkofer—viz., "that the germ of disease deodorised, but not disinfected, might be developed into active and dangerous energy." Such a contingency might happen with dried ordure; but the roots of the plants allow nothing to escape them. No germs of disease will pass by without being made to deliver up all the nitrogenous matter they contain, and which exists in everything likely to develop germs of mischief; the very minuteness of the granules themselves assisting to produce their own destruction, and in preventing the mischief which Pettenkofer has suggested as possible.

It will be asked how I prove that this is true. I answer, by experiment, and the actual results of irrigation upon the health of a neighbouring population.

If a certain weight of rye-grass seed is taken and grown in wet sand, without allowing the contact of any water which contains nitrogenous matter in its composition, the plants will grow up to a certain size—that is, until they have used up all the matter contained in the seed, and then growth is comparatively arrested, provided the supply of water is limited. I have arranged such experiments by growing rye-grass under glass. All growth has been arrested for want of nutriment. I have then added to the water solutions of fresh organic matter; the plant has at once begun to grow, and in a few days has doubled its size, whilst a test set of plants to which such organic matter has not been added remained stationary. Another basin and glass cover with sand not containing rye-grass, but to which organic matter has been added, became putrid in a few days; but no such putridity appeared in the case in which rye-grass was growing. A fourth case had put into it so much nitrate of ammonia as was considered to be contained in the meat juices which were used in the first case, but the growth of the plant was not nearly so luxuriant as in that to which the living nitrogenous matter was added; although a fresh start was made, the plant soon dwindled away and died. It is hoped that these experiments may be followed out at a more favourable opportunity. It will be found that they will show most conclusively from actual figures obtained by weighing the product what has been

the addition to each set of plants by the food supplied to them.

A point is sometimes made, by some of the opponents of sewage-farming, that chemistry has not been yet called in to prove the safety for human consumption of the food raised from sewage. The question may be fairly argued upon its merits, and its value assessed according to the evidence. The problem, however, is one which practice has solved, and if the chemist should tell me that Italian rye-grass entirely grown by the application of sewage gives chemical results, which should be considered by the sanitarian unsatisfactory and unsafe, I should answer at once that his chemistry is at fault. A long-continued use of rye-grass as a food for cattle, not in isolated and small quantities, but in quantities which may be estimated at many tens of thousands of tons, and a constant use of the products of a sewage farm in the form of milk, meat, and vegetables, has already satisfied me that his experiments would be wanting in some particulars, the absence of which had modified and altered the result. A recent writer asserted that infusions of ordinary meadow-grass, compared with infusions made from sewage-grown rye-grass, gave results which, as regards the latter, were extremely unsatisfactory. From his experiments upon such infusions he came to the conclusion that sewage-grown rye-grass contained a large amount of unassimilated nitrogenised matter, because he found

2.33 times more nitrogen in the infusion made from rye-grass as compared with that from meadow-grass. He considered it not improbable that a part at least of that ammonia which he assumed to be present in the grass, especially in the albuminoid form, was sewage pure and simple, locked up in the cells and juices of the plant. The writer advised that it is highly imprudent to feed cattle upon sewage-grown grass until a time has elapsed long enough for the plant to transform the sewage matter into proper plant-tissue. I conclude that no one will deny that an excess of strong sewage will injure plant-life, just as certainly as an excess of strong meat will injure animal life; but I have not yet met with anyone whose opinion is worth considering who had asserted that the blood of an animal can contain the organic materials which have been given as food without that material, say beef-tea, being changed into something else than the actual form in which it was given. Albuminoid ammonia cannot pass through the vital processes by which it gains admission to the animal economy without undergoing change, and that change renders it chemically different. Whilst a plant is thriving and luxuriant in its growth, the process of digestion is going on at the spongioles of the root, and when it gets too much it is surfeited and no longer luxuriant. Vegetation shows this result much more quickly than the animal economy does, for animals can escape from those in-

fluences which are injurious, but plant-life cannot; hence its greater sensitiveness to things which actually injure it. It is argued that odours are shown to be conveyed by food; that butter often betrays the kind of food upon which the animal has fed; that various matters distil, as it were, through the blood, and are easily detected in the secretions. This is true as regards certain ætherial or gaseous matters, but it is equally true that all contagia are neither ætherial nor gaseous; that they are in themselves particulate and non-volatile; that their absorption by living matter is followed by their complete transformation into harmless material.

The only useful deduction to be derived from the fact that an infusion of rye-grass contains 2.33 times more ammonia than that of common meadow-grass is, that the former assimilates sewage faster and in much larger quantities than meadow-grass, whilst the latter is rapidly destroyed by excess of ammonia. If rye-grass is hurtful to animal life because its infusion gives 22.1 per gallon nitrogen as ammonia, so does meadow-grass, which, according to the same authority, gives 9.1 only. Let the animal have two and a half times the quantity of meadow-grass, and it gets as much nitrogen as if it fed on sewage-grown grass. There is the natural result which is found to follow from feeding upon rye-grass; it produces more meat and more milk from a given weight in a certain time than does meadow-grass, because it

contains more nitrogen and nutritive matter, since more sugar is found in rye-grass, weight for weight, when dried. The result is, that a meat is produced which contains the largest amount of nitrogenous food. Rye-grass, like other highly nitrogenised food, must be given with judgment. I quite agree with the writer in question "that the quantity of sewage (that is, of manurial matter contained in sewage) a plant is capable of assimilating is limited in amount, and variable in quantity according to the age of the plant, and the external circumstances which influence its growth and nutrition;" but I also contend that some plants are able to take up more of one thing than another, that wheat thrives best when there are phosphates and silica in the soil, and even absolutely requires these matters to be provided for it. Hops do best with woollen rags as manure, and those who use them as manure get the best crops. So some plants flourish when soot is provided; others get on best with sulphate or nitrate of ammonia; and, as far as sewage is concerned, Italian rye-grass is able to assimilate and fix in its tissues a far larger quantity of the peculiar matters which are inherent to town sewage than any other of our agricultural produce—hence its value on a sewage farm, its carnivorous properties being most decided and beneficial. We find that mangold wurtzel will deal best with that which the rye-grass leaves behind

it, whilst all crops require to be alternated at times with others.

Thousands of tons of rye-grass are now yearly grown in this country on sewage farms. The grass is wholly consumed by cattle and horses. Animals choose it in preference to any other which may be put by the side of it. This is proof enough that it is good food, for animals are very discerning as to what is suitable for them, whilst the lightness with which epizoötic attacks pass over those cattle brought up on sewage farms is also proof enough that the blood of animals fed with sewage produce is not in an unhealthy state. The cattle on the Beddington sewage farm have been attacked with foot and mouth disease on four several occasions. It has always been the last, or nearly the last, farm in our neighbourhood to become affected. The disease has passed very lightly over us, seldom taking the animals off their food for more than a day or two; and, except from the loss of milk supply, giving no uneasiness at all to the manager as to the result. Hitherto pleuro-pneumonia has never appeared on the farm at all, although it has been in close neighbourhood; and the drainage from animals which have had it has reached the sewage grounds, below which some of our cattle were pastured.

We have been told by eminent men that a sewage farm is a dangerous swamp; that it is a pestiferous marsh; that it is injurious to a neigh-

bourhood; that it may be detected by the smell by an expert anywhere when he is within a mile of it; that, in fact, it stinks abominably; and that it ought not to be permitted within a mile or more of a resident population. I have simply stated the opinions of eminent men which I have myself heard given under oath before Committees of the House of Commons, or before Commissioners from the Local Government Boards, umpires acting in arbitration cases, or before jurors called to assess the damage such farms are likely to produce to neighbouring occupiers and owners. I am not, therefore, simply retailing hearsay evidence or speeches of counsel, or opinions of men when speaking upon the subject before excited audiences, but they are the *bonâ fide* beliefs of the witnesses, and as such have had weight with the judges and juries who have heard them detailed; and enormous sums have been given against the promoters of sewage farms, in consequence of the damage which is supposed to be possible to be done to the residences of those who happen to be brought within a moderate distance of any particular one. The result of these assessments has been to frighten Local Authorities from persevering in their efforts to dispose of sewage by irrigation, and damp the ardour of sanitary reformers altogether. And yet I presume to doubt the necessary sequences to these statements. I believe they cannot be supported by good evidences, and they are not the necessary

consequence of sewage farming. I believe that the witnesses have taken that which they considered as likely to happen, for a belief in that which will or has happened; and in too many instances have put the "*ergo propter hoc*" for the "*post hoc*," and thus have deceived themselves.

The Beddington Farm has been under my notice for the past seventeen years, is more or less surrounded by houses, and consists of nearly 500 acres, of which 460 are more or less under irrigation, and about 280 have been persistently irrigated since the year 1860. This irrigation has not been in driblets, but the land has dealt with the sewage of nearly 50,000 persons, now probably 55,000, night and day, summer and winter, in dry weather and during heavy rains, in continuous snow, and during long frosts. The effluent stream from it goes into the River Wandle, and then runs through several estates and gentlemen's properties, who would be extremely sensitive if nuisance were perpetrated; indeed, in former years, they used to be excessively restive under nuisance of any kind. The owners have not hesitated in former times to put the law in force against the Croydon Local Board of Health for nuisances, and certainly would do so again if they had the chance. We know how decidedly the Judges, the Vice-Chancellors, and Master of the Rolls have put their veto on the continuance of sewage nuisance; and you may be certain, therefore, that, if a nuisance had been created, efforts would have

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been made to stay it by an appeal to the courts of law by those who conceived themselves to be injured. No such attempt has been made since the effluent water from the present farm has been discharged at its present outlet—that is, for the last 17 years; and yet no farm in the kingdom has been more sedulously watched, more roundly abused, or more carefully superintended by the supporters of manure companies and competing schemes than has the Beddington Farm belonging to the Croydon Local Board of Health. Does not this fact speak volumes as to the power of vegetation to effect its object—viz., purification from dangerous animal matter? In the year 1875 the excreta of more than a thousand cases of typhoid were utilised on the farm, without a particle of injury resulting to the population around or below the sewage farm.

In stating that the farm belongs to the Croydon Local Board, I am stating one of the most serious difficulties which sewage farming has to contend with. A public body like a Local Board is about the last set of persons who are able to deal profitably with sewage. A Corporation is a body without a soul; there is power but not conscience, and the only allowable excuse for the expenditure of money is that the law compels it, otherwise nothing would be done at all. A certain portion of the members of every Local Board, elected by a large constituency, consists of men pledged to keep down the rates—not those of the future

years, but of the present day. Hence, it happens that no money is allowed to be spent unless the law compels it, or because it will bring an immediate return, and any expenditure proposed on æsthetic grounds is ruthlessly prohibited. Our farm was commenced without the power to expend capital for the purpose of farming it, and we had, in the first instance, to purify our sewage without having any stock to consume the products raised. The appearance of a sewage farm which is held by a Local Board is not one which will always be pleasing to the eye, because the general Board do not allow of expenditure by the Farm Committee for appearance sake; and the member who wishes to curry favour with the anti-rate party will loudly denounce any outlay which is for ornamental purposes, or which will only bring a return two or three years hence. I cannot point to the Beddington Farm as a model one. It has never been put forward as such; indeed, the penny wise and pound foolish policy which has been occasionally practised by the Local Board has hitherto prevented the publication of a triumphant balance-sheet; many acting masters, the majority of whom know nothing of the business they are conducting, are sure to give rise to numerous failures. The Croydon Sewage Farm has had to contend with these difficulties. It has at times been under the care of different men, many of them ignorant of farming or of natural science, and most of them

of both; but the farm still continues. As a whole, the members of the Croydon Local Board of Health are, and have been, as a class, superior in mental calibre to the majority, and have had fewer obstructives among them than are to be found elsewhere; hence the partial success which has attended our efforts.

A mean of twenty-nine analyses of the effluent water of the farm will be found on page 235, in juxtaposition with the analysis of London water as made by Dr. Frankland, and published in the Report of the Pollution of Rivers Commission. The effluent was taken from the same place as was that from which Dr. Frankland took his sample; the sewage had been over certain areas, some of which have been irrigated more or less for the last 17 years, and, compared with Dr. Frankland's analysis, which appears in the Report of the Rivers Commission, shows that there is no decrease of power on the part of the land to continue its purifying activity; and the analysis gives no support to the idea that land will in time become sick of sewage, provided the proper weight of vegetable produce be taken from it, as compared with the amount of sewage which is passed on to a given area. If, in round numbers, 50 tons of produce are annually obtained from every acre of land upon which 5,000 tons of town sewage have been poured—a ton of produce for every 100 tons of sewage—it will be found that a proper

balance has been struck, and all manurial matter has been extracted which is at all likely to be obtained. It is found impossible to get the 50 tons every year from the Beddington land. The produce of our rye-grass land gives on the average about 45 tons per annum; and at the end of two, sometimes three years, the land is broken up and planted with some other crop, as mangold wurtzel, or cabbage, or each in succession, and during the time it is thus cropped the sewage is sparingly applied, and the weight of the produce not so great. The fresh cropping takes out of the soil the matters which were not abstracted by rye-grass, and the balance is restored. In fact, the system of rotation of crops is as necessary in sewage farming as it is in ordinary agriculture. The possibility of danger arising to the health of the district around the farm is thus prevented. This is not a statement without foundation in fact; because a large area, the major portion of which is within a mile of a populous portion of the parish of Croydon, must injuriously affect that neighbourhood if miasms such as are reported to arise can be produced. It is acknowledged on all hands that the people of Croydon are not injuriously affected by any such miasms.

The district of Croydon has for many years, with one exception, shown a comparatively clean bill of health; and no one possessing any actual knowledge as to the facts has pretended that

anything has sprung up at the farm which has affected the inhabitants of Croydon injuriously.

I can even get a nearer estimate than is afforded by the parish of Croydon; for I have a numerical statement of the population and health statistics of Beddington and Wallington, from which it will be seen that, instead of introducing disease and death into the district, the introduction of the farm has been coincident with a low death-rate and a clean bill of health.

In 1861 the population of the village was 1,557; the larger portion of the people live within half a mile of the farm. In the year 1871 the population had increased, according to census, to 2,834. I have given in the table a detailed statement of the increase of population; the increase of rateable value which has taken place in consequence of the new houses which have been erected; also the totals of births and deaths which have been registered in each year since 1871. Thus—

	Population.	Rateable Value.	Births.	Birth-Rate.	Deaths.	Death-rate.
1861	1,557	£11,700	—	—	—	—
1871	2,874	20,671	94	32.7	32	11.13
1872	2,900	29,274	112	38.65	38	13.4
1873	3,360	26,328	101	30.0	48	14.3
1874	3,750	29,131	129	34.2	59	15.7
1875	3,820	29,954	129	34.0	71	18.3
1876	3,960	30,746	129	33.0	59	15.13

I obtained in 1874 from the rate-collector of the district the number of houses which were then upon

the rate-books. In the parish of Beddington they were 297, and in the hamlet of Wallington 348, giving a total of 645. They are similar in character to the Croydon houses, and most of them are situated within half-a-mile of the border of the farm, many being quite close to it. I found on analysis that the population in Croydon is 5.6 per house. This calculation, when applied to Beddington, gave a present calculation of 3,607, and, taking that as a basis, it gives an estimated death-rate of 16.9; but we must remember that one house in the place, which joins the farm itself, has nearly 200 inmates. This ought to be added to the estimated population, and then we get 15.5, which is about as low a death-rate as is usually recorded; and, moreover, it corresponds with the estimate published last year by the Registrar-General as the death-rate for that particular district, without comparing it with other vital statistics of the place. The birth-rate has also to be considered. A low birth-rate will help to disguise a high death-rate, because a high birth-rate has a corresponding infant mortality among poor people, raising the death-rate without reference to the health of the district outside the dwelling-house. It will, however, be observed that the birth-rate has been correspondingly high. In the district of Croydon the birth-rate has averaged 34.4 in the thousand; in Beddington it has been 35.7; that is, the birth-rate has been higher than in Croydon, while the death-rate has

been lower by 4 in the thousand. It has been argued that these figures may be fallacious, because the servants of those living in the better class of houses, if taken ill, are sent away to die elsewhere. This may be true, but I can get no evidence of it, and I have analysed the occupation of those who are registered as dying in the district, and I find several domestic servants who have come from situations elsewhere to die at home. They have helped to swell the death-rate to a higher point instead of reducing it. It is curious that the number of births every year during the last four years has been exactly the same. The zymotic death-rate for the districts referred to has been extremely low during the same time, notwithstanding the insanitary state of the houses, which are inhabited by the lower classes, and the universal system of cesspools throughout the hamlets.

Examining the table a little further, I find the average age at death equals thirty-seven, taking every infant at one year old. The mortality might be much larger without any blame attaching to the farm as producing an unhealthy locality, because the whole of the district under consideration has no general plan of drainage. The houses have cesspools which in many instances are overflowing, and too often in close proximity to the wells from which the inhabitants draw their water supply. In the year 1870 the medical officer attending upon the poor in the district presented

a report to the Board of Guardians as to the sanitary state of the cottages close to the farm. Mr. Creasy says in his report, "The water supply from local wells is most impure, and decidedly bad both in taste and smell." "Cesspools are in close proximity." "The cesspools are numerous and are carelessly managed." Mr. Creasy repeated these statements in a report dated April 26, 1873. Notwithstanding this honest denunciation of present evils, the Board of Guardians made no attempt to remedy things which need not have remained a single day unaltered. They are in the same state at the present time; cesspools are overflowing and water is bad, and the inhabitants only wait for the introduction of some germs to get either fever or some other epidemic, and suffer severely in consequence. It will then be said, "See what your farm is doing to these poor people," whilst the fact is that the farm has hitherto perfectly protected them from the consequence of their own want of drainage. I have taken the figures as given in the registrar's book.

I have now clearly shown that the influence of sewage irrigation on public health is not of the baneful character represented by its opponents. I contend that this alleged baneful character, if it had really existed, must have shown itself in the mortality tables ere this with considerable force, recollecting that the farm has been in operation 17 years, especially when we look at the insanitary condition of the neighbouring popula-

tion as to drainage and water supply. I wish it fairly to be understood that I do not advocate the use of effluent water from a sewage farm as potable water, but I do contend that it may be admitted into any water-course without injury to the residents, and without damage to the fish.

The Commissioners on Pollution of Rivers propose to allow any water to go into a running stream which does not contain more than two parts by weight or organic carbon in 100.000, or 0.30 parts of organic nitrogen. I have a report of the examination made of effluents from most of the sewage farms in the kingdom, from which it will be seen that the conditions laid down by the Commissioners have been generally complied with, notwithstanding the difficulties under which the managers of the farms labour in consequence of the ignorance of those in charge, and the obstructive action of designing persons. The line drawn by the Commissioners is a very low one, and does not require much care to comply with its requirements in respect to the effluent water.

I have taken an average drawn from the analyses of the effluent from the Croydon Farm; it will be seen in the table that the practical condition of that average is not very far removed from the character of Thames water, and on many occasions an analysis of the Beddington effluent has given a result which is more favourable than that which is supplied as potable water to the inhabitants of London.

Composition of Effluent Water from Croydon Sewage Farm in Parts per Million (Dr. Frankland).

	Mean of 29 Analyses.	Mean of 4 Analyses.
Total Solid Impurity . . .	390.0	340.0
Organic Carbon	6.32	5.16
Organic Nitrogen . . .	1.21	1.21
Ammonia	1.42	0.39
Nitrogen as Nitrates and Nitrites	4.15	0.29
Total Combined Nitrogen . .	6.13	1.44
Chlorine	27.18	25.70
	436.41	374.19

"These results (say the Commissioners, in their sixth report) show that in some cases drainage waters from sewage farms are less polluted by organic matters than Thames water as delivered in London for human consumption; but such a degree of purity attained occasionally at the Aldershot, Croydon, and Bedford Sewage Farms must be regarded as exceptional."

Composition of Thames Water as supplied to London in 1873, *in Parts per Million, after Filtration* (*Dr. Frankland*).

	Mean of 60 Analyses.
Total Solids	274.6
Organic Carbon	1.9
Organic Nitrogen	0.33
Ammonia	0.001
Total Combined Nitrogen	2.491
Nitrogen as Nitrates and Nitrites . .	2.16
Chlorine	18.8
	300.262

I do not see why it should be regarded as exceptional. That which can be done occasionally ought to be done constantly; and there is no reason whatever why the effluent should not always be near to the mean of four analyses instead of the twenty-nine.

In conclusion, I will just refer to the financial returns which have been obtained from the farm.

We have about 460 acres of land under cultivation. The valuation of the farm as to produce, which was made March 25, 1874, was £4,732 2s. 9d. The valuation now is £5,020. During the year 1874 we received in hard cash for milk, grass, sale of stock and vegetables, £7,256, which gives a return of, on the present valuation, about £20 per acre, as obtained from the land by sewage cultivation, not allowing for working expenses. I do not advocate cereals on the farm, but one field of wheat gave a return of fifty-four bushels to the acre, which, with the straw, made a money return of £22 3s. 9d. to the acre. I do not think this is at all equal to what it could do under different management, but we are in the hands of managers who are not the responsible heads, and who are paid salaries which are inadequate to command first-rate talent. It happens, therefore, that we do not get the best returns, or make so much profit as would be made if the farm were under the care of an accomplished agriculturist.

These are points, however, with which medical men have comparatively nothing to do. A good

financial statement would not compensate for ill-health; but, if with good health a pecuniary result is shown which obviates a great loss to the rate-payer, I think there is every reason why we should not continue to throw away a manure which will help to enrich the kingdom at large, and assist to render us independent of the foreigner for our food supplies, whilst at the same time it will diminish the price we have now to pay for meat, and assist to bring milk within the reach of those who cannot now get it for either love or money. I fully believe that sewage may be utilised in close proximity to the mansion of the nobleman, as well as the cottage of the poor man, without injury to either sight or smell; but, on the contrary, it produces a continuous verdure which is most beautiful to the eye, as well as healthful to the atmosphere.

In order that an approximate idea may be formed as to the profit and loss of a sewage farm, I annex balance-sheets of the Beddington Farm.

Financial History of the Beddington Sewage Farm.

It will be interesting to know the actual cost which the Beddington Sewage Farm has entailed during the past ten years upon the ratepayers of the parish of Croydon. The information as to the figures is obtained from the accounts which have been published year by year according to law by the Local Board of Health, and which have been audited by the Government auditor. They show receipts and expenditure only, and are not a correct statement of profit and loss, such as an accountant would draw out; but they show the real burden which has been entailed upon the parish of Croydon by the utilisation of the sewage upon land. There will not be much difficulty in apportioning the items to their proper position in the matter.

The first portion of the farm was laid out as a sewage farm in the year 1860; it was taken on lease by the Board when they were in great straits and under heavy penalties, the then lease-owner was paid out at some cost, and the land laid down for the purposes of irrigation in the cheapest possible way. It was then leased for a term of years to Mr. Marriage. The accounts as published commence with a simple statement of receipts from Mr. Marriage, and of rents paid to the ground landlord. How Mr. Marriage fared

cannot be shown, but if his evidence, as given to the Commissioners appointed to investigate the subject of the utilisation of sewage, is to be considered as correct, he was not dissatisfied with the result. In addition to these simple sums, there is a charge on the one side of wages paid to foremen employed by the Board, who made a daily report as to the condition of the effluent water at the outfall, and also the costs incurred in straining from the sewage its more solid matter before it passed on the land. On the other side is placed to the credit of the Local Board the sum which accrued by the sale of the solid manure thus obtained.

The year 1871 shows a great increase in the amounts. The rapid growth of the town of Croydon soon made the 300 acres which were used for the purpose quite inadequate to cope with the quantity of sewage which reached the outfall. It became necessary for the Board to acquire extra land. The negotiations for this purpose were conducted in the manner they generally are when the negotiators are bidding for popular favour. The shadow is grasped instead of the substance, and the interests of the parish are sacrificed. Everything connected with this negotiation was publicly known, the owners of property knew the position of the Board, and, with their own agents among the members of the Board, they knew how much rent it was possible for them to get, without any reference to the real

value of the land. The Board, having obtained the land, advised by their engineer, declined to deal with Mr. Marriage, but leased the whole of the farm to a company, which was ostensibly got up for the purpose of taking it over, and was called the Croydon Sewage Farming Company. Arrangements were also made that the Company should pay rent in advance, on somewhat corresponding terms with those under which Mr. Marriage held the land, which appeared to make the Board stand in the position of receiver of rents, paying them over at the end of each quarter to the ground landlords. The Company paid no valuation for going in, beyond sums for ordinary fixtures and small matters left in the land by Mr. Marriage. The Company commenced their work with a small capital (nominally of £10,000), of which one-fourth was paid up—sufficient to pay the first quarter's rent. They borrowed money of their bankers to pay their wages' sheets instead of making calls, paid handsome sums to their directors, clerks, managers, and other advisers; then 15 per cent. dividend on their first year's work, nothing whatever on the second, and collapsed altogether on their third. The Board had then to step in and become the actual managers of the farm, after it had been allowed to get into a ruinous condition by those who were totally incompetent to look after so large an interest. Good fortune, however, did not forsake the Company, although

they paid no valuation on going into the land; the lease had been so drawn that when it ended they received a valuation, according to the custom of the county, and under that clause the arbitrators and umpire saddled the Croydon ratepayers with a considerable sum as valuation; and in the payments for 1874 the sum of £5,238 figures as paid to the receivers of the Farming Company—a large portion of which consisted of items for rye-grass cultivation, rents, and fallows, which were not paid for when the Company took possession. However, the substantial shareholders in the Company were some of the inhabitants of Croydon, and they got back a large part of that which they had invested, notwithstanding the heavy items with which the management had been weighted.

The tables show that the receipts which have been obtained by the Local Board amount to the aggregate sum of £39,317 14s. 3d., whilst on the other side the payments have been £50,605 13s. 4d. This total shows a balance against the ratepayers of £10,891 19s. 1d.; this item, however, may be fairly reduced by the sum of £5,450 2s. 7d., which was the valuation of the stock, produce, and fixtures on the farm on the 25th of March, 1876, according to a valuation made by the farm manager, and which is on the basis of that allowed to the Company. This table gives, therefore, an average loss of £500 a year. I have appended the details of the past two years, from

which it will be seen that a Local Board labours under very great disadvantages in carrying on a business like farming. The wages' sheet alone will prove this, for there is no one in office whose pecuniary interest it is to keep down the expenses. Idle hands are retained; too often every man's hand is against the Local Board, and in favour of the private individual; the managers themselves, as soon as they become acquainted with the work that is before them, make violent enemies of those men whom they have prevented from fattening on the rates, whilst they secure but few active friends among the better class of the community, who generally decline to take part in local politics. The result is, that at almost every election the management is partially changed, and the advantages of former experience are lost. Still, notwithstanding all the disadvantages of the case, and taking the last year as a guide, it will be seen that the balance against the parish upon the working of the farm is £2,317 13s. 8d., but against this may be set-off the increase in the value of stock upon the farms, which amounts to the sum of £775, leaving a charge upon the rates of about £1,542; this amounts to the sum of a little more than one penny in the pound.

It is right to mention that no account is taken of the purchase of 56 acres of the land in question, which is now the freehold of the Local Board. For this land £8,000 was paid, and a rental should be charged on account of it.

Nothing is charged in the accounts for expenses incurred in laying out the land in the first instance, which cost £4,010; and no account is taken of the first outlay for sewers. These would have to be made under any system of sewerage, and should not be taken account of in weighing the pecuniary merits of a sewage farm. If, however, it would be thought right to charge for laying out the land, and a rental for the freehold, a further sum of £750 a year must be added, raising the total cost of the farm to a rate of something under $1\frac{3}{4}$d. in the pound upon the rateable value of the parish. Against this, however, may be put, as a set-off, the fact that there are expenses which have been incurred in the first years of the farm of the character of unexhausted improvements, which will, year by year, be adding to the income, whilst the expenditure will not again recur. I should have said that the land is leased for 21 years from 1871; long before that time is out I trust the utilisation of sewage will be so understood as to render it unnecessary for a renewal of the leases upon the present onerous and unsatisfactory basis. If the whole of the land had been obtained on the same terms as were the 56 acres before alluded to, the entire sewage of Croydon would have been utilised without any cost at all to the inhabitants; and even now, if the farm could be managed in a satisfactory manner, the receipts would be quite equal to the payments, notwithstanding the rental

of more than £10 an acre, which has to be paid for a large portion of the land.

A few words, in conclusion, as to the effect upon the health of the district in which the farm is situated. The last return of vital statistics shows that 26 deaths and 60 births have been registered as occurring in the sub-district during the past half-year. This fact bears a most important relation to the working of the farm. The neighbourhood is yearly increasing in population, rateable value, and general health, notwithstanding the fact that during the past year the farm has had to provide for and utilise the sewage of a very large number of persons who have suffered from typhoid fever. My own conviction is, that the sooner sewage is conveyed to the country and at once utilised the better for the town. The receipts and vital statistics now published I think prove that it is also no drawback to the land itself. There is one other point worth mentioning as lowering the value received from the farm—the great amount of water which has had to be dealt with during the past year. Excessive flushing of the sewers and heavy rainfalls, much of which still passes into the Croydon sewers, have taxed the land to the uttermost. This year will see an improvement in that direction; a large part of the surface water will be abstracted from the sewers and sent into its proper channels. Market gardening operations also have been given up in consequence of the impossibility of a Local

Board dealing properly with them. Market gardening is peculiar, and requires every turn of the market to be watched and provided for. A delay of two days will probably make all the difference in the profit and loss account. Thus, if the manager does not get his crops in first, he not only loses the profit, but incurs a loss. I look, however, to the accounts as likely to give a better idea of what a sewage farm will be able to do under efficient management.

BEDDINGTON

Condensed Statement of Receipts

Dr.

RECEIPTS.

	£	s.	d.
1867	1,548	8	0
1868	1,558	10	0
1869	1,562	10	0
1870	1,325	8	0
1871	4,826	14	2
1872	3,820	0	1
1873	2,207	5	11
1874	8,851	18	1
1875	7,256	0	0
1876	6,760	0	0
Total	39,713	14	3
To Apparent Loss	10,891	19	1
	50,605	13	4
To Apparent Loss brought down	10,891	19	1

FARM.

and Payments—1867 *to* 1876.

Cr.

PAYMENTS.

	£	s.	d.
1867	1,219	10	4
1868	1,221	11	3
1869	1,264	10	6
1870	1,701	14	11
1871	3,746	2	0
1872	5,182	17	7
1873	3,203	8	8
1874	13,351	19	4
1875	10,636	5	1
1876	9,077	13	8
Total	50,605	13	4
By Value of Stock and Produce on the Farm, March 25th, 1876	5,450	2	7
By Loss to the Parish of Croydon on ten years' working ...	5,441	16	6
	10,891	19	1

BEDDINGTON

Statement of Receipts and Payments

Dr.

RECEIPTS.

	£	s.	d.
Sale of Milk	825	9	11
,, Grass	1,973	0	9
,, Mangold	707	3	9
,, Wheat	126	11	3
,, Straw	52	18	0
,, Cabbages	673	10	0
,, Potatoes	251	19	3
,, Roots	0	10	0
,, Swedes	2	10	0
,, Walnuts	5	14	0
,, Hay	308	0	0
,, Seeds	2	1	0
,, Wallflowers...	0	5	0
,, Greens	296	14	1½
,, Parsnips	2	16	2
,, Onions	95	8	1
,, Spinach	24	17	4
,, Rhubarb	76	12	8
,, Brocoli	36	3	4
,, Celery	257	18	3½
,, Sage	73	11	7½
,, Parsley	50	5	0½
,, Herbs	7	0	0
,, Leeks	9	12	0½
,, Radishes	16	2	8
,, Lettuce	4	7	6½
,, Broad Beans	20	8	0
,, French ,, ...	8	11	6
,, Marrows	10	13	11½
,, Peas	3	14	0
,, Cattle	505	12	0
,, Implements	24	16	6
,, Sewage Manure	15	8	9
Horse Hire...	5	12	0
Keep of Stock	141	11	6
Miscellaneous	2	10	0
Rents, Mr. Leeks	20	0	0
,, Moody...	100	0	0
,, Shaw	20	0	0
	6,760	0	0½
To Balance (Loss)	2,317	13	8
	£9,077	13	8½

FARM.

for the year ending the 25th March, 1876.

Cr.

PAYMENTS.

	£	s.	d.	£	s.	d.
Wages, General Labour	1,699	10	0			
,, Market Garden	993	7	8			
				2,692	17	8
Managers' Salaries				212	6	8
Insurance				16	8	5
Rates, Taxes, &c.				486	11	5
Printing and Advertising				15	19	10
Seeds				279	8	3
Implements				53	2	8
Forage				806	17	5
Coals				10	17	6
Gas				8	13	7
Threshing				34	7	1
Veterinary Charges...				48	16	0
Ironmongery				69	15	0
Harness and Repairs				15	9	11
Repairs to Waggons				82	11	7
Purchase of Cows				245	10	0
,, Horse				36	15	0
Repairs				86	18	5
Horse Hire				14	8	0
Smiths' Work				1	16	2
Iron for Smithy				5	1	6
Disinfectants				2	13	6
Bricks, Lime, Cement, &c.				16	6	4
Thatching Rods				8	17	0
Timber				27	0	9
Rick Cloth and Mats				20	10	4
Grubbing Straw				12	0	0
Auction Sale Charges				81	6	10
Legal Charges connected with Leases				65	6	9
Commission, Sale of Vegetables				85	14	7½
Sundries				2	8	10
Mr. Quilter, Rent				1,388	6	8
Mr. Beddington, Rent				1,745	6	8
Dr. Shorthouse, Rent				396	13	4
				£9,077	13	8½

BEDDINGTON FARM.

Statement of Receipts and Payments for the year 1875.

Dr.

RECEIPTS.

	£	s.	d.
Rents	120	0	0
Vegetables	2,493	5	2
Grass	2,275	5	11
Milk	847	8	1
Wheat	252	10	0
Mangolds	301	7	3
Straw	52	12	0
Tares	33	0	0
Keep of Stock...	159	16	6
Sale of Cattle	658	15	10
Sundries	61	19	3
	£7,256	0	0

Cr.

PAYMENTS.

	£	s.	d.
Rents	3,279	2	6
Rates, &c.	568	4	4
Wages, &c.	3,135	2	6
Repairs, Fences	616	14	1
Stock	764	2	2
Forage	663	19	10
Commission	122	18	8
Horse Hire	169	5	6
Seeds	240	15	6
Arbitrator, &c....	146	10	5
Sundries	466	9	7
	£10,136	5	1

PARK FARM, BEDDINGTON.

Valuation, March 25th, 1876.

	£	s.	d.
Cultivation	667	13	0
Rents, &c.	1,169	3	4
Mangolds on hand	160	0	0
Oats	78	0	0
Melon Plants	25	0	0
Seeds	5	0	0
Implements	593	8	11
Forge Tools	31	16	4
Farm Horses	603	0	0
Cattle	1,902	0	0
Manures	125	1	0
Farm Fixtures	75	0	0
Timber	15	0	0
	£5,450	2	7

[Number of Cattle bred on Farm, and included in above Valuation, 56.]

	£	s.	d.
Value of Cattle on Farm, March 25th, 1876	1,902	0	0
Value of Cattle on Farm, March 25th, 1875	1,127	0	0
Increase	£775	0	0

GEORGE HORSLEY, Manager.

REPORT UPON BEDDINGTON SEWAGE FARM, FOR THE YEAR ENDING MARCH 25TH, 1877.

It will still further assist to attain an accurate idea of the value of sewage farming if I give the return of the receipt and expenditure upon the Beddington Sewage Farm during the year 1876-77. The difficulty of management by an irresponsible committee continues to prevent the returns being as large as they ought to be, whilst the expenses are greater than would be the case if those in charge suffered by mismanagement. During that year the farm manager has been changed. About a month before the change took place the late manager was much away from the farm; as a sequence to that

absence the farm suffered in various ways, both as regards cultivation and crops. The former was neglected, and the latter arrived late in the market. It was some time before a new manager was secured, and during the interregnum much mischief resulted. The mangolds, which showed well, were not clamped early enough, so that they suffered from the severe frosts which prevailed so early last year, and nearly 300 tons were destroyed. The present manager has done much to remedy the mischief, and the farm is in a more satisfactory state as regards cleanliness than it has been for some years. The receipts compare very favourably with the statement which was made last year. It will be noted that the sale of grass was much exceeded, £2,467 being taken in actual cash on this head alone. Less hay was made for that reason, and a much smaller account appears as receipts from the sale of it. The sale of milk has also advanced from £826 in 1875-6, to £1,144 in 1876-7. It will be observed that considerable sums have been spent in unexhausted improvements, amounting altogether to £336 9s. 1d., and some back bills have also been included in the account. The charge of rent, rates, and tithes reaches the enormous sum of £5,126 8s. 11d., a charge which no farm of 466 acres could be expected to clear. In that amount, however, there is included the sum of £500, which goes into the Local Board account as rental for the freehold land belonging to the Board, and the loss of £2,227 6s. 10d. may fairly be reduced by a

portion of that amount; if to that we also add the sum which fairly represents the unexhausted improvements, the charge upon the rates of the parish for the year ending Lady Day last may be put at a small fraction above one penny in the pound. The loss upon the mangolds has made an increase to the deficit. The valuation has been made by Messrs. Fuller and Moon, and may be taken as correct. The valuation which appears on page 251 was made by the then manager, as it had not been the custom of the Board to have a valuation made at Lady Day.

Valuation of Beddington Sewage Farm, made Lady Day, 1877.

	£	s.	d.
Horses	410	0	0
Neat Stock	1,476	0	0
Dead Stock, &c.	649	11	0
Cultivation, Crops, Hay, Corn, Manures	2,615	17	6
	£5,151	8	6

It will scarcely be fair to compare this valuation with that made by the late manager, but it will be a safe data for future balance-sheets.

I may also state that the stock on the farm has continued perfectly healthy during the past year, and we hope that several matters which have been hitherto unsatisfactory will continue to improve.

It will be seen that the estimate which I ventured to make as to the cost of the farm three years since—viz., one penny in the pound in each rate—has not been exceeded, and the whole expense to the parish has been less than 1½d. in the pound per annum; this amount has been latterly reduced.

BEDDINGTON

Statement of Receipts and Payments

Dr.

RECEIPTS.

	£	s.	d.	£	s.	d.
Sale of Greens	299	3	10			
,, Parsley	5	10	8			
,, Brocoli	33	5	9			
,, Sage	50	18	4			
,, Cabbage	692	14	1			
,, Potatoes	438	1	3			
,, Rhubarb	114	11	8			
,, Leeks	0	11	6			
,, Celery	1	10	0			
,, Spinach	2	15	6			
,, Wallflowers..	34	15	3			
,, Walnuts	0	8	0			
,, Willows	1	1	0			
				1,675	6	10
,, Milk	1,444	7	8			
,, Grass..	2,647	17	3			
,, Mangold	513	4	0			
,, Hay	46	13	3			
,, ,, Cartage of	2	5	0			
,, Swedes	25	4	6			
,, Cows, Horse, &c.	833	14	10			
,, Calves	35	17	6			
,, Oats	31	1	0			
,, Wheat	5	5	0			
				5,105	10	0
Horse Hire	5	16	0			
Sewage Manure	16	5	0			
Stock Keep	211	5	6			
Miscellaneous	8	3	0			
				241	9	6
Rents, Mr. Moody	100	0	0			
,, Leeks	20	0	0			
,, Shaw	20	0	0			
				140	0	0
Balance (Loss)				2,227	6	10
				£9,389	13	2

FARM.

for year ending 25th March, 1877.

Cr.

PAYMENTS.

	£	s.	d.	£	s.	d.
Wages, General Labour	891	9	4			
,, Milk	170	8	4			
,, Grass	252	6	7			
,, Fencing and Roads	41	3	7			
,, Market Garden	656	1	2			
,, New Carriers	7	16	2			
,, Mangold	166	12	1			
,, Hay	74	10	0			
,, Swedes	13	8	2			
,, Oats	41	1	9			
				2,315	7	2
Salaries				210	16	8
Printing and Advertising				21	10	2
Coals				9	4	2
Buildings				145	7	7
Gas				19	6	6
Forage				396	18	11
Seeds				220	12	5
Waggons Repairs				78	3	10
Manager's Cart				24	0	0
Tools and Implements				57	13	6
Veterinary Charges				31	1	6
Rates, Taxes, Tithes, &c.				514	12	3
Insurance				16	8	5
Valuations (2)				63	0	0
Repairs				40	18	3
Harness				25	9	0
Horse Hire				21	12	0
Threshing				34	0	0
Purchase of Cows				150	0	0
Willow Sets				27	0	0
Fencing				30	16	2
Stop Boards, Rods, &c.				16	10	0
Pipes, Bricks, Cement				54	17	6
Land Drains—Pipes	30	0	0			
,, Wages	26	6	7			
				56	6	7
Open Carrier, Waddon Marsh—Materials	45	19	9			
,, ,, Wages	33	17	8			
				79	17	5
Expenses Mangold Sale				16	4	11
Miscellaneous				19	4	3
Rents, Mr. Quilter	1,977	1	8			
,, Mr. Beddington	1,739	6	8			
,, Dr. Shorthouse	395	8	4			
,, Local Board	500	0	0			
				4,611	16	8
Commission on Sale of Vegetables				80	7	4
				£9,389	13	2

A FEW HINTS ON THE MANAGEMENT OF SEWAGE FARMS.

Soils Suitable for Irrigation—Subsoil Drainage and Impure Effluent—Natural Preferable to Artificial Drainage—Top Dressing—Necessity for Breaking Up the Land Occasionally—Distribution of Sewage —Laying Out the Ground—Expense of Pumping Sewage—Storm Overflows—Carriers—Intermittent Downward Filtration—Assimilation of Sewage by Vegetation—Sewage should be brought into Contact with Roots—Fallacy of Deep Drainage—Iron Carriers a Mistake—Method of Irrigating—Fresh Sewage and Constant Motion the Essentials of Success—Duration of Application—Fallacies of Alarmists—Alternate System—Effects of Sewage Farms in Spreading Parasitic Diseases — Dr. Letheby's and Dr. Cobbold's Opinions—Capacity of Plants to deal with Parasites—Development of Entozoa and Trichina Impossible on Well-Managed Farms—Irrigation and Rainfall—Natural History Notes—Animals Require a Change of Food—Effects of Lowering the Water Line—Destruction of Trees—Value of Nettles as Deodorisers—Commercial Value of Sewage—Methods of Estimating—Sewage Farms a Means of Rendering us Independent of Foreign Food Supplies.

Soils Suitable for Irrigation.

If it be determined by any Local Authority that the sewage of a district can be utilised by irrigation, the Medical Officer of Health is sure to be consulted as to the soils which are suitable for the purpose. It is thought by some irrigationists

who advise Local Boards as to the best method of dealing with their sewage, that any kind of soil, if it is but grass land, will serve their purpose. But the reader will have gathered that land must be properly laid out and judiciously cropped if the sewage is to be properly utilised and the effluent water restored to purity. Soils which are naturally tenacious, or continually wet, will not do for the purpose, unless the land is under-drained. Deep drainage is not, however, to be entertained in every case without due reference to the character of the soil. We must provide against the possibility of an imperfectly purified effluent finding its way into the deep drains, and thereby polluting the stream into which it passes. The best areas for sewage irrigation are those which drain themselves without any artificial aid. It does not matter at all what are the chemical characteristics of the soil if the substratum will become moderately free from water a few hours after the distribution of sewage upon it has ceased. This natural drainage is much more important than the chemical characteristics of the soil. All kinds of soil, if rightly managed, are capable of purifying sewage. The watery meadows on the banks of the Kennet, which have been taken by the Reading Local Authority, have a very absorbent arenaceous soil, yet they produce abundant crops of grass. Some of the richest water meadows in the country are near to Standen, in Berkshire; they possess

scarcely more than six inches of mould above the gravel. Beddington Sewage Farm, again, seldom has more than nine or ten inches, and in some parts scarcely four inches, overlying the shingle, yet the roots of rye-grass readily penetrate the stony bed. I have also been informed that some of the best meadows in the kingdom are to be found in Gloucestershire, which have a subsoil of clay. Adhesive clays do not answer so well for irrigation unless the soil has been treated by deep ploughing, and has had an addition made to it of long manure and ashes. If clay land is kept under irrigation for a long time, the pores become choked and the sewage scarcely penetrates at all; so that, unless the greatest care be used by the manager, there is a chance that the water may not be sufficiently purified, especially if there is not a growing crop of rye-grass on the ground.

A good loam upon a porous subsoil drains naturally, and dries as soon as the distribution of sewage ceases, and this is the best land for the purpose. If too arenaceous, or too porous, it may be as disadvantageous as a stiff clay, as it will allow the sewage to filter through too rapidly. It will not do to sewage a thick bed of gravel unless it is deeply covered with some kind of soil, but sand, fine gravel, or chalk is not an objectionable subsoil.

There is a decided difference of opinion as to the propriety of under-draining land which is intended to be used for sewage irrigation. *Primâ*

facie evidence would show that it is right to drain the land about to be so used by a deep system of drainage, so as to keep the ground as dry as possible. It is, however, manifest from the very nature of things that the land cannot be dry; that if there is any other outlet for sewage, it will soon find its way through that channel, and sewage, but not pure water, will flow off. Experience has shown that this is certain to occur. Rats, worms, and leeches rapidly develop in the carriers, and make holes through which sewage will find its way without ever coming into contact with either the vegetation or the soil, and the whole may fail; because, if sewage gets into the ground below the upper roots of the crops, there may be at times putrefaction and its attendant evils. I should advise, therefore, that the surface of the ground be so prepared that the sewage must run over it —not into it, or, at any rate, that it shall not percolate into it until it has passed over the surface; that, if the land will drain itself, under-draining is not necessary. In those cases in which subsoil draining is not ordinarily required, the most important point is to get the water off the surface without its penetrating to a greater depth than is sufficient to get into the small furrows which carry the effluent off. If the surface is regulated aright, and no deep cuttings made, there will be far less danger of evil, and a very great expense saved. The farmer would lose much nitrogen if he were to let his

guano get deep into the ground, and would stare if told not to trouble himself about top-dressings, but to plough his manure in three feet deep. Deep draining may help to account for Mr. Hope's missing nitrogen. The gardener likes his manure on the top of the soil, because he finds from experience that his crops are better if the manure is kept on the surface.

For sewage farming an argillaceous soil is more suitable than a sandy one; though it will be always best, if possible, to have a farm consisting of both kinds of soil—the one for some kind of produce, the other for different varieties. It will be essential that the soil should be capable of drying itself after irrigation; otherwise, some kind of deep draining will be necessary. If subsoil draining is introduced, the effluent water should always go over land an extra time before it is allowed to pass into a stream. Of course if, from some local cause, it is not possible for land to get moderately dry during the intervals of irrigation, and so allow of intermittent aeration, then deep draining should be resorted to, and this will promote fertility; but the outlets will have to be closely watched. The drains must be designed with great care, and laid very deep, so that an intermittent downward filtration is established. The objections to this course have been already stated, and they must be fairly considered before the plan is adopted. The action of sewage in developing a kind of clayey matter also necessitates the breaking

up of the land at frequent intervals, and argues in favour of a course of long manure and dry ashes occasionally. This necessity for breaking up grass land was not at first thoroughly understood on ordinary sewage farms, and will have to be considered more in detail.

Distribution of Sewage.

The plan upon which a sewage farm should be laid out is most important. I will give it a little more in detail, so that those about to engage in that undertaking may understand something of this part of the subject. For financial success, it is requisite that the land to be used should be below the level of the town, in order that it may be commanded by gravitation. A scheme which necessitates the operation of pumping sewage to a higher level should only be engaged in when it becomes a positive necessity, and I can hardly think that this is ever likely to happen in an ordinary inland town, especially those which are situated on the banks of running streams. In such cases there must be land on a lower level, which can be made available without the sewage being raised at the outfall.

The annual cost incurred in the operation of pumping sewage will greatly interfere with pecuniary success; a sewage farm ought to be successful, both commercially and sanitarily. It may be, nevertheless, that the difference in the

value of the land, or rather of the price paid for it, may compensate for this extra expense; but I think that great efforts should always be made to avoid the cost of pumping, and thus diminish the annual working expenses to the lowest possible amount. Engineers generally find a pumping scheme the most satisfactory, because it is easier to get land at a high level, and they calculate on being able to keep the rainfall separate from the sewage; but I do not think this can easily be done, and I would strongly urge that the sewage should gravitate for a distance of eight or ten miles, if necessary, rather than the expense of pumping machinery should be incurred if it can possibly be avoided.

Lifting sewage entails an immediate outlay for engines and rising mains, independently of the cost of pumping; if these charges are calculated and capitalised they will generally amount to a sum which will more than cover the increased cost of land and the extra length of sewer, besides the difficulties which arise from the impossibility of keeping out all the rainfall from the sewers, with the serious risk of flooding, and a necessity for storm overflows in any case.

The land should be laid out in such a manner that the sewage when delivered may be evenly distributed over the ground. It should be arranged so that the liquid should flow from the larger channels into the smaller carriers, much in the same manner as the blood is conveyed into

the extremities, except that the carriers are semi-cylinders and exposed to the air, instead of being closed tubes. They should get smaller, until at length they are only channels six inches deep by nine broad. The land should be made to slope, so that the bottom of the last carrier should be above the level of the ground on either side of it, and they should terminate at a distance of from ten to fifteen yards from the lowest part of the ground where the effluent channels take their rise. These latter channels should indigitate with the sewage carriers, and yet be kept so far apart that only by gross carelessness can crude sewage find its way into them; and they should always be slightly banked up, so as to offer an impediment to a clear course from the carrier to the effluent channel. The level must be such that the sewage shall never stagnate upon the land, that it shall keep moving, and not a single gallon should ever rest until it has passed out of the soil into the effluent stream, after which stagnation should also be impossible. The boundaries of the plot should have a channel deep enough to drain the subsoil to some depth. If this is about four feet below the level of the principal carrier which delivers the sewage upon the land, and the land itself is sufficiently porous to allow it to drain off easily, everything will be done in the way of drainage that is requisite. If, however, the soil is retentive, this treatment will not be always sufficient, and it may then be necessary to deep drain the

whole. I am, however, adverse to deep drainage if the land will dry itself without it. Should the ground be such as to require draining for ordinary agricultural purposes, subsoil drainage will also be necessary if the land should be used for sewage farming. If, however, it should not be considered necessary to deep drain under ordinary circumstances, and with the ordinary amount of rainfall, it is no more needful to do it because the land is to be used for sewage purposes—a serious expense may be saved, as well as a defect, which may possibly arise in connection with the drains, avoided.

The Croydon Farm has been most relentlessly attacked by eminent sewage authorities because it is not under-drained. Its present state, however, is a standing proof of the hollowness of theory, when opposed to the results, and when practice has proved the contrary method to be right. It proves also that circumstances sometimes alter cases. By one body of obstructives we have been charged with ignorance of the first principles of farming, and been roundly abused on that head. Another class agree that the sewage, to be completely purified, must percolate downwards at a right angle to the surface of the soil. They advocate the plan called intermittent downward filtration, which is described by the Commissioners in their first Report upon Pollution of Rivers, page 128. These writers think sewage farming on a large scale to be wrong.

Intermittent downward filtration may be, and undoubtedly is, useful in those cases where it is impossible to get land for broad irrigation, and in some seaside places in which it can only be obtained by raising the sewage to a considerable height. But I cannot think it to be the most serviceable to the State, for if the sewage enters the land and passes beyond the reach of the roots of the crop its value is lost.

If the interchange of elements by which sewage is resolved into the class of salts which indicate so-called previous sewage contamination does not take place, putrefaction must arise at some time or other, and the ground may become reduced to the same state as that which prevails in large towns which have been riddled with cesspools. The land becomes saturated with the elements of sewage matter as soon as its assimilating power has been overtaken, and then trouble must arise to those who live in its vicinity. Ultimately, when the state of super-saturation is reached, the soil is injurious to vegetable life. Such a condition is seen in rich morasses. In this manner a pestilential marsh may ultimately be produced; some persons, indeed, consider that all sewage farms are, or will, come to that state. If sewage penetrates beyond the reach of the rootlets, there will be an actual loss of useful material, the crops will suffer, and the financial results will not be so good as they might have been, and ought to

be. If the organic matter that is in the sewage is at once taken up by the vegetable kingdom, there will be those "quick returns" which are the essence of healthy business. The principle of transfer will be the more effectual when it is immediately carried out, and larger profits will be ensured. Less vital power is required to transform organic matter in the sewage into vegetable produce than is required when that matter has been already changed into organic and inorganic salts. It may be shown that a weak solution of urea, or of a solution containing a minute quantity of albumen or sugar, will grow much more luxuriant crops, if the required mineral matter is at hand, than a solution containing the same amount of organic matter changed into its corresponding simple bodies, obtained from the chemist's laboratory. It must be necessarily correct to keep fertilising matter near the surface of the soil, in order that the essential matters shall not penetrate deeper than the roots of an ordinary annual plant can reach, so that they may be absorbed before chemical changes can have advanced too far for profitable return. Mr. W. Hope, following upon the analyses of some distinguished chemists, has endeavoured to prove that not more than half the nitrogen contained in any manure is ever utilised by plant-life, and that half the value which exists in manure is, and must be, altogether lost. This is easily accounted for on the principle I have

mentioned. It is necessary that nitrogeneous matters should be kept near to the surface if they are to be assimilated by the crop, and the closer this plan is adhered to the greater will be the agriculturist's return for his sewage or manurial dressings. For this reason it is necessary that the carriers should continue to grow smaller and smaller, so that there shall be an equal distribution of sewage over the land. Another reason for having the carriers gradually diminished is to prevent so great a rush of sewage as would channel the land in improper places, and lead to such alterations of level as would allow of stagnation occurring.

It is necessary also that the manager should keep his eye upon these carriers whenever the sewage is on the land, in order that it may be spread evenly, and not escape in rushes by means of those irregularities which may exist on the best prepared lands. A slight channel becomes enlarged in a few hours if the land is not carefully watched. The position of the effluent channels should be so arranged that a stream from the field into the effluent channel ought never to exist. When the land threatens to become channelled, the sewage should be taken off that field and turned upon another until the first one has become dry, and the whole of the contained sewage has passed off into the effluent stream. Most of the sewage farms I have visited have their carriers for immediate delivery too large and

too deep, and this is the case on our own farm at Beddington.

In laying out a farm I should advise the engineer to imitate Nature as much as possible, and arrange for the carriers to diminish in diameter and depth by gradual degrees, and not to let the sewage stagnate in them in the manner that is now generally done. It is necessary in places to arrange so that the penstock shall allow of a head of water to be kept, so that the carriers may be flushed clean; but this must be done with care, and in such a manner as not to wash down the banks and enlarge the carriers during the time that it performs its proper duty. The principle I have mentioned is suggested under the idea that the first application will be to rye-grass. No sewage farm can be satisfactory unless rye-grass is made the staple produce, except the area under irrigation is far larger than towns generally are likely to attempt at first.

I am not enamoured of the iron troughs which are occasionally used on sewage farms; it may be necessary, and a decided advantage in some situations to use them, but it is a pity to lay out land which absolutely requires the use of iron-pipes. They will be a constant source of great expense. The iron soon corrodes, and in a few years the troughs are altogether worthless; and, if continued, will have to be replaced with new ones. It is true they take up no room, and allow all the land to be cultivated beneath them. It is, how-

ever, useful to have a few long moveable wooden troughs, which may be simply narrow boards nailed together like a water-spout; they are necessary for conveying liquid over plots which do not require sewaging. They are of more use in the market garden than on an ordinary farm. They are useful also in conveying sewage from the carriers to headlands which are not ordinarily sewaged, but which have occasional dressings applied to small plots. These arrangements can be easily made by any manager who has a little common sense; and a man who is deficient in that essential ought not to manage a sewage farm, for he will require to exercise his brains in determining the mode of procedure almost every time he goes on to the farm.

The plan upon which a sewage farm should be managed is of great importance, and must be arranged upon a proper principle. The land has to deal with the sewage at all times and at all seasons, during wet weather as well as fine, during frost and snow as well as heat. It follows, therefore, that certain portions must be always kept available for use in the case of any emergency arising. If there is no crop upon the land, it may still have the sewage supplied to it at intervals, care being taken that it shall not be applied too long to the same plot; but I strongly object to land being without a crop unless it is actually being prepared for one. If the plot is one hundred yards from the top carrier to the bottom, where

the effluent stream is situated, the sewage should never be allowed to pass on to that particular plot longer than is sufficient to allow the effluent to begin to flow. The supply at the top should then be changed to another plot. When the effluent carrier has run dry again, the supply of sewage may be renewed. It will be found that it reaches the effluent carrier more quickly the second time than the first, and the third time than the second time. If it is repeated too often, the soil becomes too much loaded, and the water is not so efficiently purified. In that case, if the application is still continued without the land being cultivated, it acts on the principle of intermittent downward filtration only; but, if the ground is broken up and planted, the tendency of the rootlets of the young crops is to keep the ground much more porous, and, in addition to the act of filtration, the plant-life absorbs organic matters, and fixes them without any communication with the soil at all. It is necessary, therefore, for the manager to consider this, and apply his sewage to fallow land with great judgment and with constant supervision. A great deal may be done in this way even in winter, if the sewage is not applied too constantly. Land that is to be sown in the spring with some kind of cereals may be fairly treated by successive dressings of sewage half a dozen times over without risk. This course may be continued if the area will allow of the cultivation of cereals, but should not be

adopted unless the area is ample, for cereals do not pay.

This is the best plan of dealing with such sewage as is usually found in a water-closet town which has a good supply of water. It must be fresh sewage. If it has been allowed to stagnate, if the sewer has been simply an elongated cesspool, if there exists a heading up by which it has been allowed to be quiescent for several days, if it has been kept quiet in so-called settling tanks, then it is not fresh sewage, and the farm will not be a financial success to the same extent as it might have been; for putrefactive changes, which will greatly depreciate its value, will have taken place in the sewage, and render nuisance possible. In an ordinary water-closet town with a fair fall, under the most unfavourable circumstances, the sewage may be two, three, or four miles away within six hours of its collection at the water-closet or sink, in which case, or even if twelve hours intervene, no evil will be likely to arise, or any depreciation of value to neighbouring property result.

It is necessary for perfect success that the sewage should be always moving, and hence my objection to tanks of any kind, or to sewers as receptacles for getting a head of water. No heading back should ever take place until it is on the land, when it becomes necessary, so that carriers may be full to overflowing, and the land commanded. In every case, it becomes quite

requisite that the stop-boards which are used to fill up the carriers should be removed, and the carriers well flushed every day, so that no deposit shall take place in them from which nuisance may arise.

Length of Time that Sewage should be Applied to a Given Plot.

The opponents of sewage irrigation argue that, whilst the crop is growing, some portion of the sewage will become attached to the stalks of the grass above the reach of the absorbing ends of the roots; and hence, of necessity, putrefaction will take place in a portion of the materials supplied, and miasms dangerous to the health of the neighbourhood may thus be produced.

At first sight there seems some foundation for this argument; but the dense mass of rootlets I have mentioned as being present when rye-grass is the staple produce, and through which it has to filter, soon render it innocuous in the hot seasons, when it is alone likely to occur, and with other kinds of cropping the chance will not arise. In a dry season, in the youngest grass, and when rain does not wash the plant, such a change may possibly occur; but Nature has fully guarded against that contingency by making the changes produced by the growing plants overtake and destroy the evil. The production of ozone takes place in an irrigated field as well as at the seaside. The oxygen that is given off by the rapidly-

growing rye-grass upon the Beddington Farm is ozonised. A double purpose is obtained by sewage irrigation. Not only are the noxious elements contained in the sewage seized upon by vegetation altered in their chemical form, and their constituents fixed in the tissue of the plant, but should any of the sewage products advance beyond the point at which they are valuable—should they lose that value by putrefaction, and set free vibriones and their attendant miasms—then the development of ozone, which is continually taking place by the act of growth of the plant, prevents the flight of the miasm in a dangerous form, oxidises it on the spot, and renders it harmless. Thus the antidote is coincident as to time of production with the bane. The conditions present, if a proper care has been used by the farmer, prevent the possibility of that state in which all free oxygen has been removed, and which Pasteur has described as the point at which epidemic diseases may arise.

It is worthy of remark that the effect of putrefaction is greatest at those times during which vegetation is most active, and that whatever promotes the one will promote the other. The action that takes place in vegetation after a frost is most marked. The rise of sap in trees is very active indeed, and absorption is most rapid in the plants on irrigated meadows at the break-up of a frost. It is true that the product may not appear to the eye so great as it does on a fine

summer's day, but it is certain that a given quantity of material produced in spring, when compared with a similar amount of nitrogen and carbon fixed in summer, will be *cæteris paribus* equal, whilst it is the excess of water that will make up weight. The concentrated absorption which takes place in February will as effectually purify the water as the more active growth of June and July, if a sufficient area be used, and the soil is not allowed to become surcharged with sewage.

A great point has been made by the opponents of sewage irrigation, before those Parliamentary Committees which enquired into this subject in the year 1870, of the dangers arising from sewage clinging to the stalks of grass and other crops out of the reach of the rootlets themselves, and great dangers were said to be certain to arise from it. The imaginations of the witnesses who deposed to these dangers were shown to be very active, and under cross-examination they were clearly proved to have been so. The witnesses certainly testified to the possibility, but they could not show that any evil had yet arisen from the cause; and it was conclusively shown that, although possible, it was not probable, because such a system of irrigation could not belong to properly-managed sewage farms. Some portions of a field improperly laid out may so suffer, but a field that is badly laid out ought not to be used for sewage farming at all; and sewage ought not to be allowed to go on the ground so abundantly as to flood the crop

above the rootlets, unless the crop is young and some time is to elapse before it is taken from the land, in which case no harm will arise.

Crops nearly ready for gathering ought not to be, and never are, sewaged on proper sewage farms for some days previous to cutting. Thus the agriculturist who applies sewage to his crop of rye-grass, or anything else, shortly before it is ready for cutting, is acting wrongly, and disregarding a well-known axiom of sewage farming, and is not only setting up the chance of a possible danger, but is also losing some of his financial return. This is no argument against sewage farms, but a strong one for the dismissal of incompetent managers. A farmer cultivating his own land is never likely to act so, because it is clearly contrary to his interest, since by so doing he would lose a portion of his manurial property by using it when it is not wanted. He might just as well apply fertilisers to a crop of wheat ripe for the sickle, or to a crop of turnips just ready to come off the land, as to a crop of rye-grass ready for the scythe.

The time of application to a particular plot should not exceed that which is required for the effluent channel to fill. This may be twelve hours, and when that point is reached the next plot should be used and the first allowed to dry itself. A judicious arrangement of plots on the part of the manager renders this an easy matter, whilst, as regards the application to market garden produce, no regular rule can be estab-

lished, but much must depend upon the weather and kind of crop. It is never right to apply sewage direct to any market garden produce. Cabbages, spinach, onions, and lettuces do not require it whilst they are growing. Their use is mainly to abstract those manurial properties from the ground itself which the rye-grass does not exhaust or require, and crude sewage is not to be applied to such crops except at the time of planting, and for a short time after. Great judgment is also required as to time and manner, and that judgment at present can only be gained by experience. Rules for agricultural guidance might be laid down in a book, but it is something like cricket—best learnt in the field from a man who knows how to play; so it will be best to learn from one who knows how to manage a sewage market garden or farm.*

It is not our custom at Beddington to apply sewage to rye-grass for about ten days before it is cut, and no sewage is applied to market garden produce after the plant is well rooted in the ground. Cabbages may be sewaged whilst young, the ground in which they are planted may be well sewaged before the plants are put in, but to sewage cabbages after they are fully grown is a serious mistake. So again with celery, a crop which grows wonderfully well upon

* The farm should also be so arranged that the effluent should always go over a second or a third plot before it passes away.

sewaged ground, but the plants are not sewaged at all after they are fully established; in its early life celery is capable of utilising an immense quantity of sewage.

The Effect of Sewage Farms in Spreading Parasitic Diseases.

There are other charges made against sewage farms—viz., that they will promote the spread of parasitic disease among both cattle and human beings.

The late Dr. Letheby wrote, in a paper upon the prospects of the sewage question—"There is another and very important objection to the system—viz., the danger of propagating parasitic diseases." He drew a terrible picture of the consequences likely to accrue, and brought Dr. Cobbold, our highest authority upon this subject, to support his view of the case. According to Dr. Cobbold, there are 3,000 persons in London suffering from tapeworms, which must be daily discharging millions of eggs; and, in his opinion, much danger must necessarily arise from this kind of excreta being used for the purposes of irrigation, because the average number of parasitic cases will probably occur everywhere. He had himself (he says) taken a handful of large entozoic parasites from the Craigintenny meadows. Mr. Alfred Smee also supported this idea before a Committee of the House of Commons, and fully subscribed to the evidence given by Drs. Letheby and Cobbold; but

on cross-examination not one of these witnesses could give a single instance in which serious results had actually occurred.

From a table which is published in the "Transactions of the Institution of Surveyors," and which was submitted by Mr. R. B. Grantham three years since to that body, it appears that nearly 5,000 acres of land are now under irrigation in England alone, and yet no result of the kind indicated by Dr. Letheby has as yet taken place. The estimate of area under irrigation is fully borne out by Mr. Hewson's report to the Rochdale Corporation. As regards the district of Croydon, enquiries have been made of the medical men practising in the place, with every desire to get at the truth. Especially have these enquiries been made of the medical officers attending the poor. Their reports have been continually examined, but there is no evidence of any local prevalence of the disease. Many medical men practising in Croydon have never met with a case of tapeworm, although a large portion of the meat fattened at Beddington, and other produce of the farm, comes into the Croydon market.

Supposing Dr. Cobbold's theory with regard to London to be correct, that about 1 in 1,000 has tapeworms, there should be, at the same ratio, in Croydon at least 150 subjects of this disease now discharging ova on to the sewage farm; and the dangers resulting from this discharge must have been placed freely within the reach of the residents

of that town. If Dr. Cobbold's theory had been borne out by subsequent facts, these parasitic germs must have developed and shown themselves ere this—at any rate, among the cattle on the farm. As they have not done so, we may fairly calculate that, if seventeen years' experience will not develop the presence of the supposed evil, it is not likely to arise at all.

If the theory were correct it would tell against all systems of dealing with fresh sewage, and not only against irrigation. If sewage is to be applied to the land at all before it is exposed to some destructive chemical process, the danger would be as great in the one case as in the other, and safety could alone be obtained by prohibiting the use of human excreta—or, indeed, of any animal excreta—in agriculture. Fortunately, Nature's Great Designer has not left humanity so unprotected. Vegetable life can, and does, appropriate and destroy the germs of parasitic disease as well as those of every other kind of organic matter, when they are presented to plants in a suitable manner. The proper form is sūspension in water, and to this condition all manurial products must be reduced before they can be made beneficial to agriculture. There is also another important fact—that the ova of parasites do not get upon the land at all, except by accidental floodings. In the ordinary course of sewage farming, they sink down to the bottom of the stream, and roll along until

they develop into some other form, and that form is not the tænia. The changed condition under which parasitic ova are placed entirely prevents the possibility of their developing into tapeworms, or any other form of parasitic life. The vitality of parasitic ova is not everlasting, any more than is that of the ova of birds. I believe that a change of character arises, which enables parasitic ova thus discharged to develop into *naids*, another class of annelidæ of corresponding structure, instead of those of parasites which inhabit the alimentary canal. These red-blooded worms may be seen, in immense quantities, in any channels conveying sewage when sufficient time has elapsed for their development to take place, but they are never observed in those channels which convey effluent water alone. Their presence is to me a conclusive proof that a given stream is contaminated with human excreta. I believe that there is a real change taking place in the development of the ova, in consequence of the altered circumstances in which they are placed. I have traced the tapeworm ova from their original condition, as taken out of the sewer at the outfall, and have watched the development in the sewage in its various stages until a naid has appeared, and I have been unable to make out any line of demarcation which separates the one from the other. I have not been able to take the ova of tapeworm and transplant them into a place in which no ova of naids can possibly find

admission, so that I have not the actual "*experimentum crucis*" in the matter; but I have every reason to believe, both from analogy and observation, that the idea I have expressed, however it may be opposed to the ideas of some physiologists, is correct, and that the first origin of the naid in the streams which convey sewage is the ova of those parasites which inhabit the intestinal canal of human beings; that, by the change which takes place in the ova, it will be impossible for any such to return to that parasitic condition which is injurious to human nature. Whether the ova of the naid transferred to the mucus membrane of the human intestine will become a tapeworm, I know not. Further experience is required on this point, which I hope to follow out at some future period, unless the matter is anticipated by some more energetic student of Nature than myself.

I submitted this idea to the Croydon Microscopical Club in March, 1872, a report of which appeared soon afterwards in the *Times* as follows:—

"THE SUPPOSED DANGERS OF SEWAGE FARMS.

"Dr. Alfred Carpenter has replied to a question raised by the Croydon Microscopical Club, as to the possible effect of the ova of entozoa upon human beings through the operation of sewage farms. He states that the subject is one which

has engaged a good deal of his attention ever since sewage farms were established, and he had given the matter his serious consideration. He has had occasion to express the opinion that, although the dangers feared might arise, they did not. It was found by reference to the books of the Poor Law Medical Officers, by enquiries of his own medical friends, and by his own experience, that cases of *tænia solium* were all but unknown among the inhabitants of Croydon. When cases did occur, it was generally (not invariably, of course) among those who had lived some time in India, in some part of the centre of Europe, or in Africa, showing conclusively that the ova developing the disease had been planted in the human frame in other countries. People who made the charges against sewage farms did not know anything about the management of them, and described them in a manner contrary to fact. They supposed that the ova of entozoa would be carried on to the land, applied to the crops, and then consumed as ova by the cattle on the farm. This idea showed at once their want of knowledge as to what sewage farming meant. No such contamination could occur, except by accident—such as might happen in any kitchen where meat might find its way into the cook's hands with *trichina spiralis* or other parasites in it, and was not properly cooked, or was eaten raw. If people cooked their meat properly, no evil could result; and, if sewage farms were properly

managed, no danger from entozoa could arise. Of course the possibility of such an accident was to be guarded against, but it was not sound argument against a sewage farm, any more than it would be sound policy to prohibit the consumption of meat in the kitchen because of the possible danger of *trichina* in that which might be badly cooked.

"With reference to another point—the destination of the millions of ova of entozoa which undoubtedly do find their way into the irrigation farm at Beddington—Dr. Carpenter states that he searched for them years ago at the outfall, but never found them. He thought that a good work might be done in solving the question of development by following out a point which he had not hitherto been able to do. He had an idea that the ova of entozoa placed in other channels, in other conditions as to moisture and temperature, might develop into some other form than that of parasites. He had not found the ova of entozoa, but in every running stream exposed to the air he had never failed to find the blood-red worm — the 'naid'—waving its body about. It was contrary to received opinion that such a development should occur, but whence the 'naid,' and where were the parasitic ova of the entozoa? With reference to the latter question, Mr. Henry Lee, the well-known naturalist, has offered to place at the disposal of Dr. Carpenter an apparatus which he has at Brighton, and

which can be submitted to the action of a running stream as long as may be necessary. The solution of the problem is important, as tending to prove the fallacy or otherwise of one of the supposed dangers of sewage farming."—*The Times*, March 30, 1872.

I have passed a stream of ordinary water through sand containing the ova of tænia, but without success, the naid not being forthcoming; but in the experiment there was no food for the young naid to develop upon, and I do not think it satisfactory, neither would such an experiment be likely to be so unless strained sewage was used as the proper pabulum; and in that case who shall say that the ova of parasites had not escaped the strainer?

Irrigation Compared with Rainfall.

It may be fairly asked, In what way does the effect of the application of sewage from an ordinary water-closet town differ from a heavy rainfall? The ordinary rainfall of the South of England equals 26 inches per annum, applied at irregular intervals. The present continuous supply of sewage to the Beddington Farm averages 3,000,000 gallons daily. This supply is distributed on about 45 acres of land, more or less (but it is somewhat increased on those days on which rain is super-added), the aggregate amount being about 297½ tons to the acre. This is the

sewage of about 1,200 persons for a day, and equals a rainfall of less than three inches. If a calculation is made, it will show that 10,184 tons of sewage pass on to each acre of land in the course of the year, which gives a daily average of less than 28 tons. This is equal to about 100 cubic inches in the year, to which must be added, in addition, the amount of ordinary rainfall. If we take the average daily supply of sewage to the Beddington Farm at 3,000,000 gallons, and the weight of a gallon of sewage as being equal to ten pounds, and the average of land under irrigation as 365 acres (I take this number for sake of calculation, the actual number being over 400, and, therefore, the quantity of sewage per acre is much less than the figures which I have taken as the basis of calculation), each acre will utilise 3,000,000 gallons in the year, equivalent, in round numbers, to 12,500 tons of sewage, which is about the amount produced by 123 persons. If the whole of the sewage was passed on the land at one time, it would cover it to a depth of about $11\frac{1}{2}$ feet, which is equal to a rainfall of 138 inches. This is really distributed at irregular intervals, some, however, falling upon it in most months in the year; and it is not, therefore, out of the way, or even positively excessive, and on no one day is it greater than occasionally falls naturally as rain.

There are many places in Great Britain and Ireland which have a much greater rainfall than

this. Mr. G. J. Symonds states that the average rainfall in Borrowdale equals 165 inches, Leathwaite 140, Langdale 111, and Ambleside 80; and he remarks in some notes appended to the meteorology of the district, which is published with "Jenkinson's Practical Guide to the English Lakes," it is not unusual at Leathwaite to have a fortnight or more without a single drop of rain. Notwithstanding a rainfall of 165 inches, there is no under-draining required of meadows situated a few feet above the level of rivers in the Lake District; land drains itself dry in a most rapid manner, and the fertility of its grass-lands is most marked. It is only the lands which receive water from the mountains, and which are unable to clear themselves in consequence of obstruction below the point of outfall, that require draining; and on these the rainfall would amount, if calculated in the same way, to three times as many feet. It has been remarked by the late J. F. Miller, in the "Philosophical Transactions," that, notwithstanding the heavy rainfall, there are not those extremes of heat and cold that are met with in the more Southern counties of England. The mean temperature of Chiswick is much the same as the Lake District, but that the extremes are far greater at the former place than in the more Northern counties. Mr. Symonds concludes his observations by remarking that the caloric evolved in a sensible form, by the condensation of such enormous volumes of vapour, no

doubt tends greatly to modify the climate of those sequestered localities.

This modification will be produced in a smaller degree by the action of sewage farms when they have been established in those districts which have a low rainfall. They will help to render the extremes of heat and cold less, and bring the temperature of the district nearer to the medium than it now is. This will be in a small degree, it is true, but I contend that it will be in a right direction ; and, if it brings about a state which is nearer to an equalisation of only a single degree of temperature, it will do much good to the country, and no harm whatever.

Natural History Notes.

There are many points which occur occasionally on a sewage farm that are worthy of being recorded.

When the Beddington Farm was first laid out, the land was, in an agricultural point of view, very poor, but it produced splendid elm and ash trees, which showed that the water-line was not far off. A considerable number of these trees existed on the estate, and many fine ones are still to be seen, greatly increased in size since the land was laid out. One of the first charges made against the farm was, that the use of sewage killed the timber trees. A large number certainly died soon after the ground was levelled. It was

observed, however, that these died because in levelling the soil the roots had been ruthlessly cut all around them, and that they were simply destroyed by the process of levelling. Some time afterwards a second series faded away and became skeletons of their former selves. These were mainly ash trees. It was seen that their deaths had been caused by the cattle gnawing the surface and barking them all round.

When horses and cows have been pastured for some time upon sewaged land, and restricted to rye-grass and water-grasses only, there seems to be something wanting in their system which leads them to eat with avidity the fibrous matter contained in the bark of wood. They probably resort to it with the same gusto that a man would to bran bread who had been fed for a month upon trout and champagne as his only food.

Experience shows that it is not a good plan to restrict animals entirely to rye-grass; indeed, it is no more right or comfortable to the animals themselves than it would be to keep a man entirely upon beefsteaks. Animals should be given some other food occasionally, so as to obviate this craving. Some tough, fibrous fodder will be the best for them. Chopped straw, salted and mixed with a little rough hay, suits them exceedingly well. It has been necessary to tar the trees in the fields to preserve them from the attacks of the animals pastured there. The wisest and the best plan in the interest of the farm, however, is that animals

should not be pastured at all on those fields which are irrigated, except for the short time which elapses between the last cutting and ploughing up old rye-grass lands, or upon those fields which are used for storm waters only, and upon which the water-grasses grow most abundantly.

Another fatality has been observed on some of the fields. In a very dry season, as in last July, a whole row of elms shed their leaves, and indicated a disposition to cease growing. This result occurred in two or three seasons on those lands which were not at the time under regular irrigation. It seems to have been caused by the irregular distribution of moisture. A similar result is sometimes observed on a highway along which a sewer has been laid, by means of which the water-line has been lowered many feet below its former level. All the elms affected by the drainage, especially if the subsoil is perfectly dried by means of it, die, and stand as skeletons of their former selves. The continued irrigation of a certain plot raises the water-line in that plot, or near to that field, and makes the elms, for the time being, grow most luxuriantly; but as soon as the irrigation becomes irregular, or very moderate in amount, the water-line in the soil sinks to a much lower level, and the larger portions of the roots of the elm, being defrauded of their accustomed supply, languish and die. This is generally the case whilst the land is under market garden culti-

vation; the destruction of these trees is watched with much interest by the farm manager, who wishes all the trees on the irrigated land out of his way. They are not wanted, and sewage is not applied to promote their growth. I should advise, therefore, that where it is practicable all timber trees should be removed from irrigated lands. They render a portion of the ground unfit for the rapid growth of food supplies during a great part of the year, and, when heavy rent has to be paid, they burthen the rest of the land with a heavier charge than would be the case if there were no timber on the estate.

At the same time, when fine spreading elms are seen upon a property, it is an evidence of a good subsoil, and a regular water-line.

A shrewd old farmer said to me one day, "If you are looking out for a farm, and want to know the nature of the soil—especially if it is agricultural land—look at the elms; if they are good fine trees, if you see plenty of strong chickweed and frequently beds of nettles, that farm will pay well for proper cultivation." There was much shrewd observation in the old farmer's maxim; the presence of nettles indicates richness of soil and unexhausted manure. It is most wonderful how the nettles spring up at the edges of the carriers and on those sewers which are fixed near to dwellings, and it is wise to let them grow. The large quantity of ozonised oxygen they give out seems entirely to deodorise the smells naturally

proceeding from a sewer. Of course, on the farm such things ought not to be allowed, but they may fairly be left at the edges of those open sewers which run near to high roads, or are close to inhabited buildings, for two reasons: first, they tend to prevent the flight of miasms on hot days, when such germs may be evolved from the sewer deposits which will occasionally occur in consequence of twigs and other things that find their way into open sewers; and, secondly, they help to keep away what one may call impertinent curiosity. People are not over anxious to pry into a ditch which is protected by such "touch-me-not" guardians, and it thus happens that open ditches may run very near to dwelling-houses without the inhabitants being at all aware of the nature of the contents, and thus are altogether protected from the consequences of that ideal damage which would probably result if they knew that the ditch, which was enshrouded by luxuriant vegetation, was conveying sewage! The power of nettles in deodorising noisome matters, and giving a tangible warning to intruders who might otherwise be injured by the matter which they guard, is another evidence of the wonderful provision Nature plans to protect men from hidden dangers. It teaches also that observation and an imitation of Nature's plans may help us to avoid many of those dangers which constantly beset our path. They always indicate the whereabouts of the cesspool in old ruins.

Commercial Value of Sewage in Theory.

It has been said by a very competent authority that analysis gives no difference in the character of the sewage from a midden town compared with that of a water-closet town. The River Pollution Commissioners state that there is a remarkable similarity of composition in the sewage of both kinds, and that whether human excreta are passed into the sewers or not does not seem to make much difference. A somewhat similar statement was made at the Society of Arts' Conference. In discussing Dr. Voelker's paper, it was stated that, no matter how many times the earth in Moule's closets might be re-dried and used, the manurial value was not increased after the first application. This is an anomaly which I do not pretend to understand. We are accustomed to consider the value of sewage as dependent upon the quantity of ammonia it contains, and which is supposed to be of animal origin. From Messrs. Lawes and Gilbert's analysis, published in 1866, it appears that about 12½lbs. of ammonia were contributed annually by each person in a given population. Dr. Letheby and Messrs. Hoffman and Witt have pursued a similar method of calculation, and quoted even larger results than Messrs. Lawes and Gilbert, and Dr. Thudicum confirms their conclusions. It may be that the richer sewage of the simple midden town may explain the variations in their figures, and

that sufficient allowance had not been made for the average of 45 gallons of water per head per day, which is generally added to the sewage of a water-closet town. It shows, however, the absurdity of any Sanitary Authority endeavouring to regard slop water and ordinary washings as being outside the pale of sewage. It seems to be retrograding, instead of advancing, when slop water is not considered as sewage. It must be apparent that water which has been used for washing purposes, whether of human beings, dirty clothes, or kitchen utensils, must contain as much refuse matter as is present in the excreta; and, if such refuse should be allowed to pass into the sewers, there is no reason why the excreta should be kept out. But there is the anomaly still, and it shows that there may be chemical changes taking place in ordinary sewage, previous to its discharge at the outfall, with which we are unacquainted, or that the quantity of ammonia which passes into sewers from animals helps to make up the amount which should be missing in those places where human excreta are kept out.

Some eminent analysts calculate the value of sewage as dependent upon the quantity of ammonia it contains. Mr. W. Hope has put it very clearly. He values it at a farthing per ton for every grain of ammonia which is contained in a gallon; so that, if six grains is the average amount, then the sewage is commercially worth $1\frac{1}{2}$d. per ton. Mr. Hope thinks London sewage ought to be

worth 2½d. per ton. This may be found to be the case many years hence, but at present I should be inclined to think a penny per ton would be an ample payment, even if delivered at the point and at the time when it is wanted.

Another plan of calculating the value of sewage is to reckon it at so much per head per annum. Baron Liebig estimated the value of London sewage to be about 15s. per head.

Messrs. Hoffman and Witt take the annual value at 11s. 9¼d.

Mr. Mechi, when giving evidence before the Select Committee on the Sewage of Towns, considered its annual value to be 16s. per head.

The mean of a considerable number of comparisons and estimates, according to Mr. B. Latham ("Utilisation of Sewage," Folio 6), gives, in round numbers, 8s. 6d., but he puts, as the theoretical value, 8s. 4d. per head. "At the same time it must be taken for granted," says Mr. Latham, "that its theoretical value cannot always be realised, as in every case the cost of transport and distribution must be deducted from its theoretical value, before the actual returns can be ascertained."

It is easy to fix a value at per head, or at per ton. It is not so easy to give correct data for arriving at a solution of this problem, because there are difficulties in knowing how many persons supply the sewage for a given number of acres. It might be thought that Mr. Blackburn, the

lessee of the Aldershot farm, would be able to do this with accuracy; but on asking him the question he says, "That the troops are often out of barracks for many hours, and he cannot tell with certainty which men use the closets."

In other districts, such as Croydon and Romford, all houses are not connected with the sewers, and the number of animals in the district is not known. The returns of money actually received by the Croydon Local Board of Health for the produce of the farm, irrespective of the capital employed, of the rental paid for land, the cost of labour and management, has not risen above 6s. per head; whilst, as the cost of land is larger, the labour required is greater, and the results of management unsatisfactory when in the hands of a Local Board, it is evident that correct data for guidance have not yet been attained.

One thing is manifest—that, even if 6s. per head per annum can be obtained by a moderate investment of capital, there is legislative error if sewage be allowed to be thrown away. I was greatly struck with the difficulties which stand in the way of progress, by the contents of three separate columns which I read in a local paper a short time since.

The first report was an account of an inspection of an immense sewer, which had been constructed, at great cost, to take the sewage of Beckenham, Bromley, and other West Kent towns and villages away from the land to which it belongs and cast it

into the sea. The sewer is of enormous size, and is made large enough to take in a portion of East Surrey.

The column next to it gave the evidence of a well-known cattle-dealer, who had been examined as a witness by the Committee of the House of Commons which was then investigating the causes which had led to the introduction of cattle plague into the Metropolis. That gentleman gave it as his deliberate opinion that it would be impossible for this country to raise meat enough for the wants of the people without the importation of foreign cattle—that is, it is quite impossible for the land to provide for the necessary herds.

The third column contained a report of the Committee of Management of Croydon Sewage Farm, which was signed by myself as chairman, and which reported the fact that four head of cattle had been sold for £24 each. They were two years and one month old; had been brought up entirely on sewage-grown produce, and fed on nothing else, except a few pounds of linseed-cake during the five weeks preceding their sale. They were sold to a butcher, who immediately slaughtered them. I had an opportunity of tasting a joint which I had dined off on the day on which the report was presented, and I can state most positively that I never tasted better meat, seldom having had beef so good. It was not fat, but exceedingly tender and juicy, and no epicure could wish for a better joint of meat.

Each acre of the Croydon Sewage Farm can raise produce sufficient for at least three beasts; probably two acres will feed seven such; whilst it must be a good farm indeed that will, under the ordinary system, support one bullock for each acre of grass land. I commend this fact to the attention of those interested in the welfare of the nation. If we are to become independent of foreign countries for cattle supply, it will not be brought about by throwing our sewage into the sea and importing diseased animals to sweep away our herds by cattle plague. Those who desire to prepare against emergencies will do well to arrange their sewage works so that an acre of land may be able to support three beasts on it, and as each 100 persons in the land will produce sewage for one acre, the sewage of the country could be so arranged that 20,000,000 of people could have 400,000 more horned stock in the country than they have at present; and in the event of a war with foreign powers, in which case the ports from whence we draw our extra meat supplies might be closed against us, 400,000 extra stock would be indeed a boon.

SANITARY EDUCATION IN ELEMENTARY SCHOOLS.*

Spread of Infectious Disorders in Schools—Difficulty of Dealing with the Subject—Negligence of Parents — Magisterial Difficulties — Dirt conducive to Disease— Washing should be a Branch of Elementary Education and Practice—Culpable Neglect, and Results of in Schools and Workhouses—Ophthalmia and Scald-head—Dirty Clothes and Infection—Lavatory, Baths, Laundry, and Drying Closets Essentials of Healthy Schools—The Whitgift School —Precautions against Scholars conveying Infection—Rules for Guidance—Yverdon House School—Scarlatina Outbreak at—Dr. Carpenter's Report on the Causation—Suggestions for Preventive Measures—Suggestions Adopted by Mr. G. Meyrick Jones in 1874—Subsequent Freedom from Recurrence of Outbreak.

[The question as to the closing of schools when they have become centres of infection, during the prevalence of an epidemic, is one which has caused great trouble to Medical Officers and Sanitarians ; the more so since, unfortunately, the pecuniary interests of the schoolmaster or mistress is in direct antagonism to those rules which are dictated by a sound knowledge of the laws of public health, and those principles which should guide us in our conduct as health preservers. The following paper and correspondence which has taken place on the subject of school regulations will probably be of service to the Medical Officer and attendants in dealing with such cases.]

Some important points connected with preventive medicine which require serious consideration have

* Read at the Social Science Congress, Glasgow, October, 1874.

been forcibly brought to my notice since the passing of the Elementary Education Act. Various questions arise as to how the parent or guardian, the school-manager, and the magistrate should act in those cases in which infectious disorder is assumed to exist, or to have recently been present in a particular family. A most important question bearing upon the spread of epidemics at once arises—viz., Is it possible to prevent the spread of infectious disorders whilst the attendance of children at elementary schools is to some extent compulsory?

Again, Is the excuse which is often urged by parents (that the children have had the measles, or whooping-cough, or chicken-pox), when summoned before the magistrate's court for the non-attendance of their children at school, to be considered sufficient to excuse the parents from performing their duty? Ought children who have been in possible contact with such diseases to be kept from school as long as any chance of infection exists? If the answer to these queries is in the affirmative, it appears that the children of the very poor in a thickly-peopled district need never get to school at all, especially if the converse is to be held good—viz., that parents and guardians who send their children to school whilst they are in a possibly infectious state shall be liable to some kind of punishment.

The questions I have propounded clearly indicate that there are great difficulties in the way of

a hard and fast line for their settlement, and that it may often be advisable in apparently corresponding cases for an opposite rule to be adopted by the magistrate in deciding a course of action. There are three distinct classes of persons to be considered :—

1st. Those who send their children to school to get them out of the way, and who consider their own comfort before the safety of anybody else. This class will start their children to school with measles, or whooping-cough, or even scarlatina, in the house, and even send the patients themselves immediately after their recovery, without caring for, or appearing to know of, the danger they throw in the way of other families, and making no attempt to disinfect their children before they send them. If the latter keep their own counsel, there is no means of finding out the imposition.

2nd. There is the class of people who do not care whether their children go to school or not, who do not trouble themselves to provide the required pence ; and if the little ones play truant on pay-days, rather commend them for it than otherwise. This class often set up the plea in the magistrate's court of whooping-cough or chicken-pox, or some other children's malady, as a reason for keeping them at home ; and if, as in these instances is generally the case, the parents are "*peculiar people*," and do not engage the services of a medical man to pilot them through the

disease, there is no certain means of discovering the deceit.

3rd. There is the class of persons who like their children to go to school. In each of the classes cases occur in which disease is so mild that the parents do not know of its existence, or the children do not show the eruption, which is the specific symptom of the disease, until they have reached the schoolhouse, or even have attended a day or two before it has been discovered. In the meantime, the whole of the children in the school, who are liable to take the disease, have been exposed to infection.

The existence of these three distinct classes of persons shows the difficulties which have to be considered in dealing out justice to the poor. It is impossible to adopt one line of conduct. Each case, whether before the Managers' Committee or the magistrate's court, must be dealt with "on its own merits," and according to the *bonâ fides* of the parents. If we consider the first class of cases, it is certain that some households are so constituted that no danger will accrue to the school from the continued attendance of children, though some members in the household may have been recently suffering from an infectious disorder. At the same time, the 38th section of the Sanitary Act, 1866, which renders parents liable to a fine of £5 for sending children to school who may spread epidemic disease, is a necessary clause, and in some cases should be

rigorously enforced. In most of them, however, it is at present a dead letter.

The plea of infectious disease often raised in the magistrate's court is sometimes true; but in a great majority of instances it is not so, and is only raised to cover the real cause, which is indifference to, or a dislike of, education because of its cost, although only twopence per week, or because the child is wanted to do something at home, or for the sake of the small pittance the child can earn. There is no medical attendant; the guardian declares that the child has a cough or has had measles or some rash last week. At times it becomes impossible to disallow the plea, and the children continue to run wild and wallow in the gutter in spite of the compulsory clauses in the Education Act.

The third class of cases it is quite impossible to deal with by fine. A child goes to school feeling a little unwell (but in some families school-children often do so); in the afternoon the scarlet rash is out, and several school-fellows have been infected. The parent did not know anything of it, and cannot in strict justice be pecuniarily punished for spreading the disease.

These difficulties might be very much decreased by taking measures to render children less susceptible of infection. A school-room containing a number of children, one of whom is sickening with scarlatina or measles, or among whom is a child recently recovering from any of such diseases, is a

hotbed in which the production of epidemic poison is rapidly promoted. It is much more rapid in its development in some seasons than in others, and among some classes of children than others. Children with dirty clothes, and who are seldom washed, spread the disease like wildfire; whilst children who are bathed every day, and frequently put on clean clothes, are not readily susceptible to take epidemics. The cultivation of the habit of personal cleanliness in elementary schools would materially decrease the risk which naturally follows upon compulsory attendance.

I propose, therefore, that washing should take its natural place, and be a part of the course of teaching in every elementary school. Actual washing should be insisted on during school hours, and a daily inspection made by the master or mistress at a stated time—an inspection which should be rigid both as to skin and clothes, corresponding to the dress-parade which soldiers have to undergo. There should be a washing and combing class, and also a clothes class. The first would have reference to the cleanliness of skin, nails, and hair; the second, the cleanliness and tidiness of clothes. Washing and mending should be attended to as a necessity as much as spelling or writing. No greater boon could be bestowed upon our lowest poor than inculcating into the minds of their children the necessity for cleanliness, and teaching them how to do it. This is a branch of a child's education which is supposed to

be taught at home; but no one can see the wretched, dirty, ragged urchins who pour out of some schools at closing time without being painfully struck with the utter neglect of the required teaching both at home and at school. There are many exceptions; but, in instances much too numerous, a slatternly, untidy habit is indulged in by the master in his own person, and of course he is not likely to control the untidy and dirty state of his pupils or be antagonistic to their teaching at home; to instruct the children how to wash, and to see that it is done; to keep their hair tidy and clean, their clothes clean and free from raggedness, would be a far greater boon to them, both in the present and for the future, than to teach them the distance of Canton from London, or that the planet Jupiter has four moons.

An occasional inspection of children in workhouse schools, as well as the evidence afforded by the daily press, has told me how this portion of education is neglected in pauper establishments as well as in elementary schools. Purulent ophthalmia and scald-head is the rule among such, and is mainly due to neglect of cleanly habits. The presence of such diseases in such establishments would be best met by a heavy fine upon the managers themselves. The injury which is done to the eyes and health of children is enormous as to its imperial cost and the dead loss which it inflicts on the country, compared to the

expense of cleaning and washing their heads, under proper superintendence. Their heads should be washed and cleaned and their hair cut in class, if disease is to be arrested, for it is quite impossible to get it done properly in the homes of many of those children for whose education elementary schools were by law established. Until it is done properly in pauper and board schools the diseases mentioned will not be eradicated. It does not follow that every child in an elementary school should belong to the class. In many instances home teaching would enable the child to pass his examination without going into class, but the requisite inspection should be daily made.

This course of education would necessarily render the addition of several things to the present requirements of the school-house. Thus, it would be requisite to have sets of clothes that might be worn by some children whilst their own were washed and mended. This would not be a difficult matter. Every public elementary school ought to have a proper washing-place, so that the children might wash the whole of the body at least twice a week, as well as their hands and face. There should also be a washing-place for clothes, with a drying closet attached, which could dry the clothes as quickly as possible, and be so arranged that cloth clothes might be cleansed and disinfected, as well as linen clothes washed.

Is the custom of wearing the same dirty

garments day after day, getting daily more filthy, an unavoidable one? It is this custom which makes the air of rooms so unwholesome in which the lower classes of children assemble, and which frequently produce the first seeds of evil in the constitution, especially when they go into the room, damp, from the effect of a drizzling rain. Everyone accustomed to a badly-ventilated school-room knows that it is the smell from damp and dirty clothes which is the principal source of the offensive atmosphere. Even if the clothes will not wash, an exposure in the drying-closet to a temperature of 350° will not hurt their texture, whilst it will entirely destroy any lurking seeds of infectious disorders which might be clinging to them, as well as destroy the seed-beds themselves; and, in the possible case of infection being brought into the school in the clothes, would, in the majority of instances, prevent it from spreading among the pupils.

Such a course of action would tend more than anything else to limit the spread of infectious disorder, and deprive it, when it did come, of much of its malignancy and danger, especially if the sanitary arrangements of the place under the control of the Local Sanitary Authority were properly carried out.

The course of instruction in mending clothes would be a boon to boys as well as to the girls. It is wonderful what a help a sailor is in some working men's households, in consequence of his

ability to mend his clothes and do little repairs to the clothes of others. There is no reason why every working man should not be as helpful in that line as an ordinary seaman can be, whilst in the case of children coming from an infected house, or ignorantly taking infection into the school, the wash-house and the drying-closet would cause the mischief to be scotched at once.

I would urge this view upon the managers of our elementary schools as one of the most important means which can be taken to render the health of the children of the poor generally satisfactory, and make them moderately independent of chance epidemics. If such did come it would have a marvellous effect in reducing them to the mildest possible form, and materially assist in shortening the necessary quarantine which is now properly required. I contend that a public elementary school should possess—

1. Access to a bath, in which every child should be required to bathe twice a week. Every day would be better still.

2. A washing-place, in which they should be obliged to wash daily.

3. A room, in which the hair should be combed and the head cleansed every day, or oftener if necessary. These operations should be superintended by some person who should see that the elder children attended to the younger as well as themselves, and so teach them to be careful of others.

4. A laundry, in which the clothes which required it could be washed.

5. A drying-closet, capable of being heated to a temperature of 400°, in which washed clothes, and also all damp garments, could be quickly dried. This would be a great boon to the children on wet days.

6. A store of needles, threads, tapes, &c., for mending purposes, the use of which should be taught to boys as well as girls, in class, as often as might be necessary.

I contend that all these are necessary for the education of the great mass of our poor, as much as, if not more than, a knowledge of geography and astronomy, or even of history. It will be impossible for the people to be godly until they are instructed in the way of cleanliness. Cleanly children will acquire a dislike for personal dirt, and retain it to the end of their lives. They will make more effort to raise themselves from below the level of brutes to that of Christians than they otherwise would do if allowed to remain accustomed to filth. Use becomes second nature, and second nature in a generation or two becomes instinctive.

It is only by educating our poorer classes in cleanliness in early life that we shall make them, as a whole, love it for its own sake, and hate dirt and those habits which tend to make man lower than the beasts of the earth, too often now arising from an acquaintance, an intimate association,

with dirt and dirty homes among the poor. Poverty may be clean, and with cleanliness the first step will have been taken to do away with the evils which follow in its train, and that health secured which riches without cleanliness cannot possibly purchase.

The following correspondence has a close bearing on the foregoing paper, and explains itself. The regulations are those which are in operation for Whitgift School, Croydon :—

The Head Master, Mr. Robert Brodie, wrote to me as follows :—" I should be much obliged to you if you would give me your opinion as to the regulations we ought to make—

" (1) As to the time which should elapse before we allow a boy to return to school, after he has recovered from an infectious disease.

" (2) As to boys coming to school from houses in which any person is suffering from an infectious disease."

To this I sent the following reply :—" The questions you have propounded to me cannot be answered in a satisfactory manner as shortly as they are put, because the circumstances under which infectious cases arise are as various as the character of the cases themselves. Still, it is possible to lay down a few general rules which may be safely acted upon.

" The 38th clause of the Sanitary Act, 1866,

ordains in effect that persons sending their children to school whilst suffering from the effects of infectious disorders (capable, therefore, of spreading such diseases), are liable to a penalty of 'five pounds.' This rule applies to scarlatina, measles, mumps, small-pox, whooping-cough, ringworm, diphtheria, and chicken-pox. Children who have had those disorders ought not to be received back again into the school without a medical certificate, stating that their convalescence is perfect, and their disinfection complete.

"This is very important and absolutely necessary to be observed in a case of scarlatina. A month should elapse from the time at which convalescence is complete before a boy who has had an attack of scarlatina should be readmitted to the school. If the case is one of measles or mumps, the time may be shorter; three weeks is sufficient for safety, provided such measures have been carried out as every family medical adviser will indicate as necessary for disinfection.

"The certificate should state the time which has elapsed since convalescence, that the boy has been fairly disinfected by proper baths, and that fresh clothing has been provided. A boy who had scarlatina two months since, but who has not had his head washed with some disinfectant, may spread the disease among those susceptible of its influence. At the same time a boy who has been

properly disinfected may return to school at a much earlier date, without the least risk to others; but it is safest to consider a month as the shortest necessary time.

"If a boy has on some former occasion had an epidemic infectious disease, he will not be very liable to take it again; and though some member of his family may have it, he might be allowed to continue at school, provided the parents gave a promise that he should not be brought into contact with the patient until the latter was safe from the chance of spreading infection.

"Those boys who have not had the particular disease from the effects of which some other member of the family is suffering, should not be allowed to come to the school whilst the disease is present at home, until they have had a fortnight's quarantine, by residing that time in some other place.

"The best protection against small-pox would be to require every boy to bring proof that he has been vaccinated before he is admitted to the school at all; and every boy above fourteen years of age to bring proof that he has been re-vaccinated.

"I think the adoption of the general rules I have indicated will be of some service in preventing the loss of valuable time, and in checking the spread of infectious disorders among the pupils of Whitgift School."

In consequence of my suggestions, the Governors

of the Whitgift School drew up the following "Regulations" for the guidance of parents and guardians:—

"Every candidate for admission to the school will be required to bring a written statement from his parent or guardian that he has been vaccinated.

"Boys above fourteen years of age who are candidates for admission, or who are already entered in the school, will be required to bring similar proof that they have been re-vaccinated since they completed their fourteenth year.

"No boy will be allowed to return to school after an attack of any epidemic infectious disease, unless he brings a medical certificate stating that his recovery and disinfection are complete.

"Parents are urged not to send their sons to school when any member of their household is suffering from an epidemic infectious disease, unless (1) their sons, having previously had the disease, are carefully kept from all contact with the patient until the latter is thoroughly disinfected; or unless (2) their sons, not having previously had the disease, have lived for a fortnight away from home, and after that time come to school from a house in which no one is suffering from such disease.

"The epidemic infectious diseases included in the above regulations are scarlatina, measles, mumps, small-pox, whooping-cough, diphtheria, and chicken-pox."

The following report and correspondence upon the causation of scarlatina at Yverdon House, Blackheath, with suggestions for the prevention of future outbreaks, may afford some useful hints for guidance in similar cases :—

" *Mems. for Consideration* :—

> " Was the disease imported and spread among the boys by personal contact ?
>
> or,
>
> " Did it arise in the school from the continuance of a cause at present undiscovered ? If the latter,
>
> " What measures are necessary to prevent the recurrence of the attacks in future ?

" Outbreaks arose in October, 1868 (when it was all but certain that the infection was imported into the school) ; in July, 1871 ; in March, 1874 ; and again in October, 1874. It was epidemic generally at the end of 1868, in 1871, and now again it is becoming prevalent in the country, so that the outbreaks corresponded with a tendency to spread elsewhere.

" Taking the present attack for specific examination, I find on October 11th and 12th four boys affected. All presented symptoms of the disease within twenty-four hours of each other. This fact proves that those boys did not infect each other, but caught the disease from some common cause.

" It does not appear probable that this came from personal contact with another case ; it was

not from contact with another boy within the school, because the four boys affected occupied different dormitories. It is reasonable to conclude that, if a boy had introduced the disease into the school, he would have infected those boys who slept in the same room with him to a greater extent than the others, whereas the affected boys were scattered in different sleeping compartments.

"It was not introduced by personal contact, by an affected master or attendant, because the attendants and masters, though numerous in the school, altogether escaped its effect. The attendants and masters, from having a more direct and frequent intercourse with each other, would have influenced some of themselves, as well as affected the boys, if infection had been introduced by their means, for only four out of sixteen of this class of inmates had had the disease previously. I conclude, therefore, that the source of infection was neither from tutors nor servants.

"On examining the class-rooms, a point mentioned by the Principal was suggestive—viz., that the four affected boys sat near to each other in one of the class-rooms. A further examination also showed that the position they occupied was midway between the middle window of the room and a door at the north-east corner. It appeared also that both door and window would require to be open for the proper ventilation of the room, and that any current across the room would impinge upon the affected boys. It appeared also that, in

the epidemic in the spring of this year, the boys first affected occupied nearly the same position.

"A careful examination of the arrangements of the house on the south side of the class-room did not reveal any cause which would lead me to suspect that the germs of disease came in by the window. The room itself gave no indication to suspect the origin of the disease within its walls. The door at the north-east corner communicated with a passage leading to a lobby, into which opened another class-room—also the boiler-house, the boot lobby, the swimming bath, and, further on still, the latrines. The boiler-house was shut off by a door generally closed, and having no necessity for communication with the school. Two doors shut off the latrines from that part of the lobby into which the class-room opened; the bath opened into the lobby between these doors. Whenever the doors in the lobby were opened, they acted as valves, or as the suckers of a piston-rod, and drew air backwards or forwards out of or into the class-room, towards or from the bath and latrines; for there did not appear to be any other means of obtaining air, when the outer door leading from the play-ground to the class-rooms was closed. Now, as the consumption of air in the class-room, when occupied by a considerable number of boys, must be great, it is evident that the draught in any circumstances would rather be from the latrines to the class-rooms than *vice versâ*, and it must be so whenever the wind is in

any other direction than S. or S.W. The principal ventilation provided in the latrine is a louvre in the wall, north and south; but the north louvre is in the most direct line with the lobby, and the fresh air coming in at that position (or even the other) must be mingled with the products of disease or decomposition (if any) escaping from the urinals. I was unwilling to think that any such did escape, everything being in good order; but I could find no evidence, either in the bath-room or the latrines for the ventilation of the main sewer; and I did find very distinct evidence that such ventilation was provided in an indirect manner, by which the foul air from the main sewer could find its way into the latrines, and thence by the lobby into the class-room. The tutors' water-closet, which was separated from the boys' and was kept locked up, ventilated into the latrine itself, and from this water-closet a most perceptible evidence of sewer smell proceeded, after a large volume of water had been discharged down from the latrines. I am of opinion that the first germs of the epidemic found admission through this closet into the class-room, and that whenever the latrines are flushed, or the bath emptied, there is an escape of foul air from the main sewer into the latrines, and thence into the class-room; and that the boys sitting at the desks between the north-east door and the middle window would be liable to get the larger dose of the fever germ, if present. We have only, there-

fore, to provide that germs of scarlatina poison shall be in the sewer for them to find their way in the manner indicated, and it is curiously suggestive that, on the 3rd, 4th, 5th, and 7th of October, the wind was in the W. and N.W. for portions of those days; there would be, therefore, a greater current in the direction indicated, whilst the prevalence of scarlatina—though not, as far as I know, positively said to exist on the line of sewer with which Yverdon House communicates—is most probable.* The arrangements in all parts of the house seemed admirable, and I could find no other evidence of imperfect sanitary arrangements, whilst the one indicated is such an one as only recent enquiries have enabled us to assess at its proper value.

"As recommendations for the prevention of future attacks, I should advise that the masters' water-closet be thoroughly examined and the soil-pipe looked to. It will probably be found either decayed in one of its bends or defective in its 'container,' the D trap being comparatively useless as a trap. I should recommend that a ventilator be placed between the trap and the descending part of the soil-pipe, which should open in the upper air; it should be 3 inches in diameter. I should advise that the upper part of the closet itself be better ventilated; that louvres be inserted on the north wall of the latrines above each

* It was afterwards found that scarlatina was very prevalent in houses connected with this sewer.

closet, and that an air-shaft be made in the lobby, by means of which fresh air may find its way into the lobby and the class-room, without being drawn through the latrine. I should also advise a ventilator to be inserted in the waste-pipe which carries off the water from the plunge-bath between a trap which should exist there and the sewer, unless the bath could be disconnected with the sewer altogether, and the waste have an indirect communication, which would be the safer plan. There should also be a ventilator upon the soil-pipe from the latrines, between its trap and the main sewer, which should be carried up some twenty feet into the air, and protected by a cowl similar to those used to obviate smoking chimneys.

"For the safety of the domestic servants, I would advise the removal of the swill-tub to some part farther from the house, and that the direct communication with the sewer which now exists in the kitchen department should be cut off; and that all communications which are for waste water and washings should go into the sewer by indirect channels only, the latter being protected by a dip-trap out of doors, which should be cleaned out every day, and the trap filled by someone whose duty it should be specially to attend to that particular work. If these rules are fairly carried out, and no water used in the establishment for dietetic purposes except that which has been drawn direct from the public supply (which I

understand to be the rule now), it will scarcely be possible for any epidemic disorder to find its way into the school except by personal contact.

"In conclusion, I may observe that it would be better for the latrines and the urinals to be entirely separated from the house if it can possibly be done. It is better for the boys to have to go out of doors for two or three yards to reach that part of the establishment, than that a channel should be at hand ready to convey evil into the school whenever an accident arises by means of which the germs of disease may be brought within danger point.

"If these germs are discharged into the outer air no evil can possibly arise, and the school will be altogether preserved from future accident.

"I think all the other sanitary arrangements of the school are in excellent order, but no system, however perfect, could exclude outbreaks of the disease in the face of the circumstances I have detailed.

"ALFRED CARPENTER, M.D.

"*Croydon, October 27th*, 1874."

The Rev. G. Meyrick Jones, on receipt of the above report, wrote that what I stated on the occasion of my visit of inspection indicated that danger *might* arise from the position of the closets and urinals. In consequence, he set about devising a plan for placing these offices in the open air. By

the removal of a large coal-house and knife-house, he obtained a sufficient space for enclosing a yard, where all the closets and urinals were re-built within a fortnight from the time of commencement. The old closets and urinals were immediately taken down. All the other sanitary arrangements which had been suggested were carried out without loss of time.

In reply to enquiries I made recently, the Rev. G. Meyrick Jones wrote on 7th August, 1877—"That not only have we been free from scarlatina since the alterations you advised were made, but the general health of the school has markedly improved. We have had very few sore throats, and those all to be traced to a chill. Sick headaches are now as rare as they were common previously. The credit of this last you must, perhaps, share with the ventilating air-shafts that I have introduced into the rooms.

"It is worthy of notice that this condition of health has been coincident with higher numbers in the school than we ever had before.

"This happy change, I have no doubt in my own mind, is due to your alterations. You are, therefore, clearly entitled to make whatever use you think right of this case to promote right knowledge and practice in sanitary matters. My wife has just reminded me that, since our last 'experience,' the disease has been on both sides of us—*i.e.*, on the same sewer."

The above case is worthy of publication; it is

one of many in which I have been able to trace a distinct connection between sewer air and scarlatina. It is always difficult to get so convincing a proof of the influence as in this particular case, which I have picked out of a considerable number of a similar kind as conclusive on the point in question.

ADDRESS IN PUBLIC MEDICINE.*

Salus Populi Suprema est Lex—Harassing Legislation—True Basis of Sanitary Science—Early Pioneers—Untried Dogmas and Permissive Measures—Engineering Knowledge Essential to a Medical Officer of Health—Registration of Disease a Necessity—Compulsory Information—Householder should be the Informant—Difficulties of Medical Officers of Health—Apathy and Negligence of Municipalities and Individuals—Prevention of Disease a Necessary Study—Duties of the Profession—Motion the First Principle in Sanitary Work—Stagnation a Cause of Disease—Ventilation of Sewers and Drains—Sewer Flushing—Utilisation of Sewage—House Drains and Cisterns—Water Pipes—Zymotic Diseases—Small-pox—Non-recurrence of Zymotic Diseases—Impurity of Blood—Factors of Disease Equations—Causes and Modifications—Prevention Better than Quarantine—Meteorology and Disease Germs—The Contagium Particle a Living Organism—Fungi, Incubation of—Gases Evolved by—Epidemic Catarrh Reproductive—Measles, when Prevalent—Filth Diseases—Rate of Mortality and the Water Line—Susceptibility of Hand-fed Children—Disease not of Spontaneous Growth—Comparative Immunity from Zymotic Disease can be Obtained, and also from "the Pestilence that Walketh in Noonday"—Conclusion.

A PARLIAMENTARY leader has spread far and wide a definite proposition : *Salus populi suprema est lex.* We are bound to believe that when he uttered

* Delivered to the British Medical Association at Sheffield, August 4th, 1876.

that sentiment he honestly gave adhesion to the principle involved in it. Nay, the harassing legislation which a belief in its correctness helped to promote has assisted to bring about the ebb-tide in the promotion of sanitary work which we are now witnessing.

It is scarcely more than forty years since the first national platform was established upon which satisfactory observations could be made, and successful operations carried on in the cause of preventive medicine. The statistics which have been prepared by William Farr have been true pioneers of sanitary work. I would by no means decry the observations made by the older sanitarians. Howard and Pringle, Harvey and Jenner, with many other older workmen, are worthy of the highest regard by those who value our object, and who think prevention of greater national importance than cure. If it had not been for the work of these eminent men, followed as it was by that of the enlightened politicians who framed and passed the Factory Act of 1833 and the Registration Act of 1834, William Farr's records would not now be matters of history, and we might still be groping in the dark as to the natural laws which regulate the health of the people, and be theorising as to the causation of disease, instead of calling upon Parliament to legislate for its prevention. The facts which have been brought to light by Farr's tables, the enormous mortality which has been shown to

exist in defined districts, among defined classes of persons, and at particular epochs in their lives, together with the philosophical and suggestive papers which have been prepared by, or at, the suggestion of one who deserves as much of his country as any living man—I mean John Simon—have led to a flood of legislative measures, sometimes contradictory, passed in paroxysms; too often spasmodic in their character and unsatisfactory in their working; but culminating in the enactment of a measure which made the appointment of Medical Officers of Health compulsory upon all Local Sanitary Authorities. This measure has laid a foundation which enables us to apply particular observations to defined localities all over the country. The compulsory appointment of those Medical Officers was preceded by a permissive stage—permissive, first, in the application of sanitary work to a particular district—permissive, in the way in which that work should be applied, but at the same time accompanied by the stern resolves of the courts of law that in applying that work, and bringing it into practice, the rights of individuals should be respected.

The antagonism between the *suprema lex* and the liberty of the subject; the opposition between *salus populi* and the rights of property, continued to throw serious impediments in the way of sanitary progress, because the truths of sanitary science were few, whilst the *ipse dixits* of its

professors, both medical and engineering, were numerous and contradictory. Especially has this been the case with the comparatively new profession of Sanitary Engineers, a profession which has sprung up to execute the works which sanitary science has called for; the members of which profession, in a large number of instances, were ignorant of natural science. Is it to be wondered at that Parliament in its wisdom passed permissive measures? Is it not a natural thing that those who had faith in the truth of their dogmas should ask for a trial of the principles they wished to be carried into practice, before making it compulsory on Local Authorities to entertain them? Was it not natural that those who desired healthy and satisfactory progress should prefer to see the suggested enactments in operation, and that they would wish to have an opportunity of studying their effects before committing the Legislature to a course of action which would have to be retraced if it happened to be projected on wrong lines.

Hence the value of permissive measures; the promoters of antagonistic schemes for the improvement of the health of the people have had a fair field; the principles upon which these schemes are based may have been correct, but unfortunately the advice of the medical expert has been but too often only half acted upon. Medical men are not acquainted with the first principles of engineering work. To engineers has been most naturally entrusted the duty of devising and carrying out the

works which are required for the removal of the causes of disease, with the too frequent result of partial failure, because sanitary law or a study of biology has not been the guiding star of the engineer; whilst the medical adviser, being totally ignorant of the requirements of the former, has unwittingly passed over serious defects in the proposed schemes. The lesson which has been learnt is, that Medical Officers of Health must know something of the first principles of sanitary engineering, so that they may be able to detect any grave defects in the works which a Local Authority may determine as requisite to be carried out in a given district. Such first principles must be a part of the education of every Medical Officer of Health, so far as they are connected with drainage, water supply, and building construction.

Registration of the causes of disease tells us in conclusive figures that disease is irregular in its incidence, that it coincides in its incidence with certain social conditions, that certain forms of disease decrease or increase as those social conditions alter for the better or for the worse. The study of the statistics of a given locality is a mariner's compass to the student in prevention; whilst the rise and fall of certain forms of disease in that locality constitutes a barometer whose daily readings point out to the pilot the course which he should steer, and advises him of coming storms. It is only recently that every place has

had its recognised pilot in the Medical Officer of Health, whose duty it is to watch the indications afforded by registrations, and to advise the Local Authority accordingly. The indications are, however, not afforded to that officer at the most important and essential time—viz., at the very onset of epidemic or infectious disease. Registration of death is not in itself sufficient for the welfare of the State. The only information which a Medical Officer of Health receives officially at present is, that disease of an infectious character has been fatal in a given place some time previously. This information is conveyed to him many days or even weeks after the event, and he finds, on inquiry, that the *materies morbi* has already been spread far and wide, that the contagia which have been produced by that case have been passed into the public sewer, the nearest water-course, or other receptacle for human excreta, and, as a consequence, have most likely multiplied indefinitely. It is also probable that many cases of the same kind occurred before one was fatal, and that no efficient steps were taken to localise or circumscribe the effects of the disease in that locality. It is more than probable that if the proper officer could have had information of the first appearance of that disease in the locality, the general distribution of its contagious particles would have been prevented, and the people saved some of the consequences of that distribution. A natural sequence to the registration of death is the registration of

these forms of disease, for the repression of which a sanitary organisation is by law established. That registration will be effected in due course. It is a coming wave of legislation waiting for the time when the natural history of those diseases which it is intended to encounter is more fully understood by the public, and more perfect knowledge obtained by ourselves as to the way in which preventive measures are to be used.

We must be agreed among ourselves, as to the proper steering course before we can have sufficient influence with the Legislature to procure the enforcement of a satisfactory measure. We must be agreed as to the class of disease which should be registered, and agreed also as to the persons who should give the information to the Registrar. I cannot support the opinion that it is our duty, as a profession, to give information to the Registrar on this point. A medical man, or, indeed, any other person, is out of place in undertaking a duty which may follow upon, but which is not a part of, the work he is asked to perform by his employer, especially if that work appears to be to the detriment of the latter. It would be morally wrong for a medical adviser to conceal the nature of a given case, if of an infectious character, from the knowledge of his employer or the responsible head of the establishment in which his employer resides; but the medical man having communicated that knowledge to him, the latter should be the party to give the information to the State, and be re-

sponsible to the Local Authority if he withheld it. The members of our profession cannot claim the protection of privilege. If called upon, they would be obliged to convict the employer of neglect if the latter failed to comply with the requirements of the law, if such a law should be enacted. The employer, or the person responsible for his welfare, should give notice, just as at present the owner of cattle is bound to send information to the inspector that disease of a certain kind exists on his farm. It was felt, when the Contagious Diseases (Animals) Act was passed, that to call upon veterinary surgeons to give the required information would defeat the object of the Act. It would no less defeat the object in the case of human beings if medical men were to be called upon to forward the information to the Local Authority; there would be an immediate premium on the employment of unregistered persons, and an effort made to suppress the discovery; and unless Medical Officers of Health are to be entirely restricted from private professional work, it is quite impossible for such an enactment to work satisfactorily to the State, whilst, under any condition, it would be unjust to the private practitioner.

The Medical Officers recently appointed have zealously set to work to find out the sanitary defects which exist in their district, and have made elaborate reports regarding the same. Many are astonished to find that although appointed to do

certain work, and to make certain suggestions for action, no action is taken, and things remain much as they were before the appointment was made. There is nothing very extraordinary in this. It is the rule in every-day life. The custom of the unit is necessarily the custom of the aggregate of units, and the Local Authority does that as a body which the majority of individuals comprising it do in their daily life. It is the same result which naturally follows when a medical man offers gratuitous advice to his wealthy patient at the wrong moment. The country is now passing through a phase of this kind; honest and conscientious Medical Officers of Health are bringing down upon themselves a shower of indignant remonstrances, of wide-spread abuse and energetic opposition from local John Bulls, who do not recognise the fact that the State is suffering from mischiefs which can be removed if proper measures are taken for their removal. The reports of Medical Officers of Health lie on the table of the Council Chamber, and very little concerted action is taken for the removal of those causes of disease which have been so ably and clearly pointed out. The patient is saying pretty plainly that he does not intend to rigidly obey the laws of health or to be doctor-ridden, and until some wave of epidemic disease arises, and compels him to reconsider his determination, he will not alter his course or take a different line of action ; he may then instruct the Sanitary Engineer to carry

out costly works which remove the most flagrant nuisance, but when carried out, they often do not effect all the objects intended, because some first principle of sanitary law is altogether overlooked.

These results, though not due to defects in sanitary science, so much as to construction of works, are leading the public to enquire for themselves and to criticise our actions. Fortunately for science, physiology is taught in some of our elementary schools, whilst honours are taken at our Universities in natural science by men who do not intend to enter the medical profession. The youth of both sexes are acquiring more and more knowledge of the laws of Nature, and imbibing the first principles of physics. A portion of the public believe that it is the duty of the physician to give a reason for the line of treatment he is pursuing; they will not be satisfied with an evasive answer, whilst the more sensible portion will not be led astray by a false one. Our explanations must be either strictly correct or so framed as to apply to a possible hypothesis, and not be contrary to the laws of natural science.

To the medical profession the country owes in a great measure the knowledge which has been obtained of the laws which apply to disease prevention. As a profession we must continue in advance of laymen, and we must not allow the idea to gain ground that prevention and cure are different studies, and may be entirely separated from each other. It may be even that the former

will supersede the latter, and become the more noble study; but to give currency to the proposal that medical men should not be called upon to consider the means to be used for the prevention of disease, and that they may ignore the operations of the engineer, would be suicidal.

We must know how to prevent disease if we would retain the confidence of the public. If we are properly acquainted with the best principles of prevention as well as of cure, our objectors will not be long in finding out that they had much better be doctor-ridden, as they style it, than put their trust in delusions. At the same time, it is our duty to advise, not to dictate; to recommend, not to command ; and to support our recommendations by arguments based on sound science. If the doctor has been unskilful, addicted to dogmatise, and to advance opinions which are not founded upon scientific truths, he is doing serious harm, and helping to promote those forms of quackery which are so rife among the idle, the self-willed, and half-educated ignoramus of society. We require a clear insight into the conditions which give rise to disease, to reduce the principles of preventive medicine to the plainest lines, and to bring it into formula which may be at once assented to ; perspicuity being the basis of all true knowledge in every branch of study.

I will set out what I believe to be some of these bases. The first principle of sanitary work

is *motion*. Any plan which entails stagnation as a part of its scheme must have the cause for that stagnation very clearly expressed, and a sound reason given for it, or the scheme is bad in design and not calculated to effect the object for which it is proposed. This is a canon law with reference to the first great purpose of the sanitary officer. From the moment of excretion until it is utilised, motion of the excreta is the first sanitary law. If the excreta of carnivorous animals are kept moving, those combinations which produce epidemic disease are not forthcoming. For this purpose sewers are required in crowded localities. They are the necessary evils which follow upon the aggregation of individuals into crowded communities, though they are quite out of place in the village and the isolated mansion. Any sewer so constituted as to allow of stagnation of any of its contents in any part of its course is wrongly made. If arrangements are introduced which necessarily produce stagnation in the air, if only for a few feet of house-drain, a manufactory or vineyard is allowed to exist in which contagious particles may vegetate, and may be the starting-point of a fresh epidemic; any trap on a sewer which is not accompanied by a corresponding ventilator may become a trap to catch men. Any sewer so constructed as to allow of deposit of solid matter, or which allows sewage to stagnate in any part of its course, is in a similar condition. Sewers must contain a current of sewage

constantly passing down, with a corresponding current of air always passing one way or the other, if they are to be kept free from the power of manufacturing mischief. Ventilation must be free and absolute, ingress being allowed as well as egress, in a way which cannot be counteracted. For every house in connection with a public sewer there should be at least two free openings provided in the house-drain, an inlet as well as an outlet. If this arrangement is carried out, and the openings contrived so as to effect the object in view, and not for the purpose of defeating it, the natural forces will more effectually ventilate the sewers than any artificial aids. The diffusion of gases, the tension of vapour, the differences of temperature, in the sewer as compared with the outer air, the constant movement of external air, together with the movement of sewage in the sewer, will suffice to produce a free ventilation at all times. If this be done, no contagium particle will have a chance of reproduction in the contents of sewers, and no sewer gas will be discharged which will convey elements of mischief.

Deposit must not be allowed to take place; sewers must flush clean. The engineer who constructs sewers so that a deposit is probable in the invert of the arch has failed to effect the object for which he was engaged, and has erected an elongated cesspool. A sewer must flush clean under all circumstances. If sewage is always moving in the sewer there will not be time for

deposit, there will not be time for those changes to take place upon which the production of contagia depend, so that motion prevents evil. Sewage must continue in motion and pass on to its destination. There is another point worthy of motion which is too often forgotten—fresh sewage does not smell. If a sewer stinks it is defective in its workmanship somewhere. It is not sanitary science which is at fault, but engineering work. Sewers which give out unsavoury odours ought not to be accepted. They are defective either in their ventilation or their levels, they are either wrongly designed or badly executed, and the engineer should be called upon to rectify the mistake.

Sewage cannot be retained in a sewer or anywhere else for more than twenty-four hours without producing a chance of evil; long before that time has elapsed it ought to be on its way to be utilised. The moment utilisation of sewage has properly commenced, from that moment the evils which might result from sewage recedes into the far distance, and it becomes ineffective as a focus of infection. At present, nineteen-twentieths of the sewage produced by the thirty-two millions of Great Britain is cast into the sea or allowed to decompose after it has set up an immense amount of disease. Some of it becomes food for fishes, but the major portion is lost for ever by its reduction to its original elements.

The utilisation of sewage by agriculture is one

of the most important actions which the political economist, as well as the sanitary officer, can promote. It is a large field for the investment of superabundant capital, which must bring a handsome return to the inhabitants of the land in which it is invested, even if the investor fails to get a large premium. If one-tenth part of the sum which has been lost in Turkish, Egyptian, Honduras, and other worthless securities, had been invested in sewage utilisation, tens of thousands of acres of land, which are now comparatively barren, might be bringing in a yearly revenue of five pounds an acre to the present owners, whilst the produce raised upon them would assist to reduce the famine price of butchers' meat, and be a boon to the country. It is just now proposed to spend ten or fifteen millions of pounds in the formation of a Channel tunnel, which, by a slight accident, may be entirely lost. A similar sum expended for the purpose of utilising the sewage of London would make 10,000 acres of barren land as fruitful as the Beddington fields, and could not be lost. Motion in contact with atmospheric air in the sewer, on the farm and from the farm, constitute the first principles of sewage utilisation. I say in contact with atmospheric air, because this is the *sine quâ non* of utilisation. Even in the next best way of dealing with sewage—viz., by intermittent downward filtration, it is an absolute necessity, although in such case the utilisation is secondary and partial only.

Experience has taught us that in dealing with sewage there are two other canon laws which are simple and absolute in their character, and which cannot be departed from without danger. One has reference to the communication between the house and the main sewer. No matter how careful the architect or the sanitary engineer may have been in his plans, the drainage portion is carried out by a class of workmen who habitually slur over their work, and studiously ignore the common laws of hydraulics and pneumatics. The natural result is occasional or even frequent stoppage. To obviate this danger, no sewer should have any direct communication between it and the interior of the house. Such communication should always be by indirect channels only. (*Vide* page 161.)

The other canon law is also as absolute. It is that no water-pipe conveying potable water for use into any house should ever come into direct contact with a sewer or house drain in any part of its course, especially at the orifice of discharge. The reckless way in which plumbers and house-fitters disobey these laws is producing danger to individuals in all ranks of society. Sewer air from imperfectly-constructed sewers is laid on to our bed-rooms, dressing-rooms, kitchen departments, and lavatories, as regularly as if it were a necessary of life, whilst the water-pipe is in thousands of instances so placed as to render it perfectly impossible to be used without the con-

tingency of air finding its way to the water from the impurest of impure sources. People reputed to possess common sense do not see the danger of such proceedings, because everyone using water liable to be so contaminated is not affected on all occasions and at all times. They argue that the precaution of keeping water-pipes away from the neighbourhood of sewers is unnecessary, because a fatal result does not immediately follow. They might as well argue that a battle-field is not dangerous because the hero of a hundred fights died a natural death in his own bed.

I am inclined to make seven distinct classes of zymotic disease (*vide* page 25), and to include among them several which, at present, are assumed to be peculiar to animals alone. But the classification includes all the diseases which appear as epidemics in this country. The conditions are analogous under which one or other of them may arise, according as a concurrence of circumstances come together or not. The first class includes small-pox, cow-pox, chicken-pox, and sheep-pox. Its reproduction requires a germ or atom of potent matter which must be introduced into the animal economy from without. Now and then an individual is found who is insusceptible of the disease. If we could discover the reason for this insusceptibility, we should get the clue to the means which are required for the entire prevention of small-pox, and even render vaccination unnecessary. Attention to ordinary

sanitary detail will not prevent its appearance, though it may diminish its fatality. A person who is apparently most healthy, very cleanly in his habits, who always inhales pure air, drinks pure water, and who is but little exposed to the influence of decomposing fæcal evacuations, may yet suffer from the disease. It is true that it is much more fatal in a dark, ill-ventilated house, with the insanitary surroundings which usually belong to such; still the fact remains, small-pox and its allies are not prevented by sanitary regulations alone, and is not so capable of prevention, by municipal and personal cleanliness, as most of the zymotic class.

A distinguished member of this Association has made out that the milder exanthem, cow-pox, acts as a preventive of the severer form of the disease, simply because it is a form of small-pox, modified by its transmission through an animal; the germ which produces it having been a germ of small-pox, changed in its nature by passing through the body of a cow. It is an instance of the way in which Providence places in our hands means whereby we may extract the sting of disease if we set about it in the right way. The recipient of the slighter disease is insusceptible of the severer form of malady for a long time—until most of the tissues of the body have been altogether changed, and new matter laid down in their place.

This insusceptibility to take on a similar form of malady a second time is peculiar to most

zymotic diseases. A person having suffered from enteric or scarlet fever is less liable to suffer from those forms of disease again. In this they differ materially from constitutional and functional diseases. If a person has suffered once from gout or bronchitis, he becomes more liable to recurring attacks. A custom has been established which will possibly set up an outlet in his system for the discharge of effete or used-up matter. It has one privilege attached to it; there is often a smaller quantity of the particular material in which the germ or potent matter of zymotic disease delights, than there is in that person who is apparently in a healthier state, which accounts for the fact that delicate people suffer less severely from epidemic maladies than those who are strong and hearty. The manifestation of zymotic disease represents the result of some potent force, or the effect of some living organism acting upon the humours of the body, and altering the condition of the system in a way which requires years to efface. It removes from the system the whole of the matter in which the active principle of infectious disease can revel, and until production of its particular pabulum takes place that special disease cannot arise again, because there is no food for the active principle to live upon. I much doubt if this potent force or living organism, take it as we please, could have any effect upon the body, if the recipient were perfectly healthy; if no impurity existed in the fluids of the body; if

the blood contained nothing foreign to a healthy and natural state. If this be so, a question arises as from whence these impurities proceed, and how their effects are to be guarded against. I venture to put forth an hypothesis for consideration, which will explain much which is difficult to understand on any other view. Some impurities must exist; they are the used-up matter, the result of the act of life, or they may be inherited tendencies, which have resulted from former neglect of sanitary law, and which have depreciated the quality of the stock, and rendered it more susceptible to bad influences. The impurities naturally increase if there are any defects in the sanitary arrangement of the individual corpus. Their presence is of no moment if they are not in excess, and if they are removed from the body as fast as they are formed, or in the course which they naturally follow. Let us represent them by x, in an equation in which the factors x, y, z (as a total) represent any form of epidemic disease. The problem is to assess the value of each factor in the equation. Divide the factors into two parts: centric elements, or those which are proper to the body; and excentric, or those which act upon it from without. Let $x = u$ and e; u being the used-up material, the formed material of Beale, always in the act of formation, it is not foreign matter, and is not in ordinary proportions injurious to life. It is always being diminished as

fast as it is formed, by one or other of the excretory organs which exist for the purpose of removing it. If all the excretory organs and all the functions of the body are healthy, and all doing their work properly, the body is in good health—there is no excess of used-up material, no *débris* of combustion. If, however, one or other of the excretory organs fails to do its duty, from either over-work or inertness, something is left in the humoral system, and e is added. It becomes a positive quantity, and represents the excess of matter which should have been removed, $u + e = x$. They have a common origin, being the *débris* of the act of living; e will differ in quantity as well as in quality. It will be modified by personal character, by actions, by non-actions, and even by attainments; but especially by attention to, or neglect of, general sanitary and moral laws. Still more will it vary according to the circumstances of the community among whom the person resides, the moral and the sanitary state, or the habitual neglect of sanitary law in which that community may indulge. Thus, a Municipal Authority who allows over-crowding, foul air, immoral acts on the part of the people, impure water, or bad food, is providing an excess of e, and increasing the danger which may arise from the introduction of the potent principle of infectious disease. If e is absent, x is not complete, and x, y, z cannot arise; x may be complete from the circumstances I have detailed, but then y, z are still required to establish an

epidemic. Let *z* correspond to an atom of potent matter, a germ or living organism, the particulate contagium of any kind of zymotic disease, the multiplying focus of infectious disorder; being one of the excentric elements in the equation, it has to be introduced from without, and is capable of modification according to the character of the soil into which it may happen to be transplanted. Like Torula cerevisia or Penicillium glaucum, the germs upon which fermentation depends, and without which alcohol is not produced; if *z* does not gain admission to some part of the humoral system, the entity, zymotic disease, cannot arise. Just as Penicillium glaucum requires the sugar and the temperature to produce alcohol, so *z*, the contagium particle, requires the food upon which it increases and multiplies, as well as certain meteorological states for its proper development. These latter conditions are represented by *y*. The severity of the disease will depend upon the quantity of *e* which exists in the factor *x*. The epidemic will be more or less general and fatal according to the greater or lesser quantity of *e* in each individual, not according to the character of *z*; *z* will be reproduced according to the quantity of food in the recipient upon which it can increase and multiply. If *e* be absent, the effect of *z* will be nothing, for there is nothing for it to feed upon. If, therefore, personal cleanliness be attended to, if all the excretory organs of the body are properly exercised, if the Municipal Authority has insisted

upon obedience to the sanitary law, if moral laws are obeyed in each unit of sanitary work, the effect of z, whenever it happens to be introduced, will be reduced to a minimum, and z may be so dwarfed as to be unable to effect a lodgment, or it may die out entirely. It will be by directing attention to the necessity of diminishing the growth of e that we shall prevent epidemics from spreading, rather than by useless attempts to keep out z; by correct sanitary administration, rather than by trying to establish an all but impossible quarantine. Let e in the factor x abound, and quarantine is not effectual; if z once passes through the cordon, the power of the latter is lost, and all our work in that direction has come to nought. The equation stands thus: $x = u + e$, and represents the used-up material, the result of the act of life; $y =$ the meteorological conditions, such as temperature, moisture, and certain atmospheric states which are required for the rapid increase of epidemics; $z =$ the contagium particle upon which the nature of the disease depends. The fatality of the disease will depend upon the quantity of e in the factor x. The rapidity of growth will depend upon certain meteorological states represented by y, but the character of the disease itself will depend upon z. We can diminish x to a minimum by personal, municipal, and sanitary arrangements; we cannot alter y, but we can impede the introduction of z, and prevent epidemic disease, unless it can be shown that zymotic diseases may arise *sua sponte*.

As regards small-pox, there is not any difference of opinion on this point. It certainly requires the introduction of z from without, however much meteorological states and personal dirt may promote its growth; and, if the contagium particle be absent, small-pox cannot arise. It has been clearly shown that the contagium particle is a living organism requiring certain forms of matter for its development, and if it do not meet with that matter its character is altered, and it is no longer the same entity.

There is a class which includes measles, whooping-cough, influenza, epidemic catarrh, and eczema epizoötica, in which z appears to be a germ of living organic matter, most probably of vegetable origin—possibly the fructification of a class of organisms which have recently been called schizomycetous, and which are too minute for separate identification with present microscopical powers. That vegetable matter *can* produce similar effects is seen in the action of the pollen of anthoxanthum ordoratum, and also in that of the fine powder of ipecacuanha root. The effect upon mucus membrane of these re-agents is not constant; it only arises in some persons. Year by year we find the persons thus liable to be affected to be more numerous. They probably have e in the factor x, in a form more susceptible of the action of vegetable matter in their systems of the kind named. The action produced is immediate, and it may be likened to that

set up by mustard. The latter immediately affects everyone alike; and thus it differs somewhat from that which produces hay asthma. The action produced by fungi is not immediate; there is a period of incubation, a period sufficiently long for the production of an immense multiplication of fungus growth, and, as a sequence to that growth, the production of a chemical result. Growing fungi produce carbonic acid or some other acid or etherial products; there is always a considerable formation of gaseous matter set free by such growth. This product can set up irritation in the tissues, just as formic acid can, if it be injected under the skin. The germination, and, as a sequence, the multiplication of fungi in acid media is one of the wheels within wheels often met with in Nature, where reproduction is more rapid, because reproduction itself produces material which increases growth. There is a marked difference between the effect of the *materies morbi* which sets up epidemic catarrh and that of pollen upon mucus membrane. The one is reproductive, the other is not. It is in the result of reproduction that the cause for the catarrh is to be found. In that reproduction, a material is set free which acts in a manner similar to the pollen of the anthoxanthum. Those who live in close ill-ventilated rooms, and who object to admit fresh air, are said to take cold when they do so. It is not the fresh air itself which injures them, but it brings into contact with the patient's

mucus membrane some germ from without, or else it disturbs some such in the ordinarily undisturbed part of the room. The fruit takes root and grows in its new home, reproducing itself, perhaps, like cow-pox, under altered conditions, and in that reproduction sets free a material which is the actual cause of the catarrh. It is not the seed, but the product of growth which produces the disease.

The effect of copaiva in producing a rash similar to, and which cannot always be distinguished from, measles, except by the absence of fever, is a proof that a vegetable product can excite a similar state. It has not been shown that the rubeoloid eruption which sometimes follows upon the use of copaiva has any protective influence against true measles. An extended series of observations are required to prove this point ; and it may be that there is an opening for information which is worth following up. Measles is more generally prevalent in mild damp seasons ; it always appears more or less about cleaning time, when old heaps of rubbish are being disturbed, and decaying organic matter from homesteads and farmyards are being spread over the soil. It appears then as an epidemic, as if there were a sequence in the operation. It is possible that the schizomycetous organisms may be altered forms of some particular mould or smut, altered in the character of their fructification, and altered in their mode of growth by transplantation to a new

home; just as the contagium particle of small-pox is altered by its transit through the humours of the cow. Alterations of this kind do occur; the connection between the echinococcus and the tapeworm is a case in point; and it does not follow that the organisms themselves are distinct species which require a continuous existence in that form for their occasional appearance as epidemics. As is the case with small-pox, so some persons never have measles, or whooping-cough, or scarlatina, though frequently exposed to the influence of the contagion. Whoever discovers the cause of this exemption will confer a boon upon humanity, as in that discovery will follow the establishment of a means for preventing altogether those forms of disease.

The class which includes diarrhœa, cholera, dysentery, enteric and intermittent fever, are essentially filth diseases, arising from the effects of a sewaged soaked soil, of polluted water, or air rendered foul by miasms from decomposing organic matter. Wherever any of this class puts in an occasional appearance, diarrhœa is certain to be a regular visitor, if the temperature rises above the ordinary standard, and continues high for any time. It has been imputed to the rise and fall of the water-line in the subsoil in connection with the rainfall of the district. A close investigation of conditions under which summer diarrhœa arises in those towns in which it is prevalent—such as London, Leicester, and Berlin—shows

conclusively that, although the highest mortality corresponds with the lowest level of ground-water, there is no relative proportion in any other point. A relation does exist between the origin of the disease and heat. The greater the heat the greater the mortality; the lower the amount of moisture in the air the higher the death-rate from diarrhœa. A fall in the death-rate follows upon the return of atmospheric saturation, and those years in which the dew point is farthest removed from the highest temperature will be found to have the greatest mortality from diarrhœa. The fall in the level of ground water, the increase of temperature, and the diminution of water in the air, all occur together. Then it is that those who inhabit cellars, underground dwellings, dark ill-ventilated houses, houses of that kind in which dry rot is taking place, all places likely to get an excess of carbonic acid in the air, suffer from the disease. Hand-fed children suffer first and most heavily. This appears to prove that the food is the principal starting point. The food, when exhibited, is about to undergo some change, promoted by living organisms, which flourish most luxuriantly under the conditions mentioned. They obtain a lodgment in the mucus membrane of the alimentary canal, and destroy the child by destroying the nourishing properties of the food exhibited. Pettenkofer thinks that locality has more to do with the disease than the introduction of any particular germ—that removal from the place will prevent or even cure the disease.

He imputes it to some influence produced upon the people by the rise and fall of water in the sub-soil. This rise and fall is connected, but it is as a coincidence, not as a sequence. The conditions which give rise to infantile diarrhœa are those which promote the growth of certain living organisms. Such growth takes place most rapidly at high temperatures, when evaporation is rapid, and when the underground air has an excess of CO_2 in its composition, together with the organisms which accompany that excess—conditions which are likely to be in association with a low water-line, conditions which are naturally followed by heavy rainfalls. The z in the equation $x, y, z =$ infantile diarrhœa, is some living organism developed by continuous heat, by dry air, excess of CO_2 in that air, and some other unknown condition. This organism finds admission into the stomach with the food; sets up a fermentation, by which the nourishing power of the food is destroyed; produces an irritating material, which, uniting with x, causes prostration; and, if this be not fatal, the child is starved to death. The localities in which diarrhœa arises are the favoured haunts of cholera and enteric fever, under other meteorological states in which heat and dryness are not contingencies. Pettenkofer considers their origin to be due to local and personal considerations, and believes that quarantine is useless. The opinion as to the latter point may be right, but it does not follow upon the former. The conditions which herald

the approach of cholera are progressive from place to place. The factor z may be brought in, and the disease produced earlier than it otherwise would if it had to wait for development *sua sponte*. In solving the power of each member of the equation $x, y, z =$ enteric fever, we may be certain that the factor z is a living organism capable of reproducing its like in any situation in which fæcal contamination has occurred, and in which the products of filth-decomposition are to be found. The rules which apply to typhoid apply with equal effect to cholera and its allies.

Do any of these diseases arise *sua sponte?* The sudden way in which some of them develop sanctions the idea. This is especially the case with enteric fever and scarlatina. Many intelligent and accurate observers have been unable otherwise to account for the appearance of those diseases in given cases. Yet, the ordinary laws of natural history would forbid the suggestion. Growths, apparently spontaneous, are common in the vegetable kingdom, but in no case is it supposed that the growth has taken place without the previous presence of appropriate spores or seeds. The sudden and wide-spread appearance of eczema epizoötica among cattle, or the destruction of potato by potato blight, seem to be spontaneous, yet those diseases spread by contagium particles; we may reasonably suppose that the propagation depends upon spores like to Penicillium glaucum or Mucor mucedo. Those

spores are to be always found only waiting for a suitable situation in which they may grow and become fertile in a few hours. They are both ærial and aquatic, and produce different results, according to the dryness or moisture of the position in which they are found, and are modified by the acidity or the alkalinity of the media in which they multiply. Bacteria of different kinds are found in one, vibrios in another; why should not those forms produce a potent matter in their growth, capable in itself of producing disease? We know that certain kinds of fish may be eaten to-day with impunity, but to-morrow they set up serious disturbances in the animal economy. Vibrios to-day may be harmless, but to-morrow they may produce disease. The secretion from the peritoneum to-day may do no mischief; to-morrow an irritative action may arise which will set up a most virulent and infectious complaint. In peritonitis, a most fatal form of infective disease may be set up, and the infectivity arises *sua sponte* because certain circumstances have been altered, and the bioplasm, existing normally in the tissues, has taken on a new action. The germs were there, but, the vital conditions being altered, a comparatively harmless secretion is turned into a virulent poison.

I believe this to be the case with those specific forms of contagion which are multiplied by filth. Scarlatina and typhus, enteric fever and cholera, arise apparently *sua sponte*, because cer-

tain germs or foci of potent matter have been altered by the circumstances in which they are placed, and infective power has been added, just as infectivity is produced in the peritoneal secretion by inflaming the membrane which secretes it. The ordinary excreta of carnivorous animals which contains the *débris* of animal food may or may not be so placed as to produce the germ upon which filth disease depends, just as dry rot may or may not arise in a building, according as to whether ventilation has been provided for and new wood kept out of the fabric. But, if those germs be introduced into the human economy, the disease arises and spreads in the usual manner. So again with scarlatina, long continued observation and analogy forbids the idea of an origin except from some bioplasm finding a suitable soil in which it may develop its poisonous character.

Time fails me to go through the list of zymotic diseases, and show the character of z in each class. There is a close analogy, a continuing alliance, and a similar explanation can be made as to the value of z in each member.

Zymotic disease, in the majority of instances, has its power of producing evil more in the character of the recipient than in the quality of z. Obedience to sanitary law in private life, together with the performance of public duty by Local Authority, will give comparative immunity from epidemic and infectious diseases, and render us in

a great measure independent of the trammels of imperfect quarantine.

That, as zymotic disease has its main impetus in the disregard of duty, those who advocate the performance of that duty must be prepared to encounter opposition and witness an ebb-tide in sanitary work. It is imperfect knowledge on our part which gives strength to opposition. It is our duty to persevere in the prosecution of a more perfect work. Motion as opposed to stagnation, simplicity as opposed to complexity, should be our cardinal points; and, if to this we add the peremptory utilisation of animal *débris*, the sting of epidemic and infectious disease will be taken away, and, in the words of the Psalmist, "We need not be afraid of the pestilence which walketh in darkness, nor of the destruction which wasteth at noon-day."

It is our duty to strive to reach this point of perfection. It can be obtained only by educating the people as well as ourselves aright, and we must trust to Providence for our reward.

FINIS.

APPENDIX.

OPINIONS OF OUR LEADING STATESMEN.

That our leading statesmen are in unison on the subject of Sanitary Measures may be inferred from speeches made at different times by the two great rival champions of politics, the Earl of Beaconsfield and Mr. Gladstone. The former remarked, on the occasion of opening one of the Victoria Dwellings Association's new buildings, on June 23, 1877:—

"That Her Majesty takes a deep interest in the movement for the improvement of the dwellings of the people, and expressed her wish that her name might be associated with the institution."

Proceeding, the Noble Earl said:—"I have touched upon the health of the people, and I know there are many who look upon that as an amiable, but merely philanthropic expectation to dwell upon. But the truth is, the matter is much deeper than it appears upon the surface. The health of a people is really the foundation upon which all their happiness and all their power, as a state, depends. It is quite possible for a kingdom to be inhabited by an able and active population; you may have successful manufactures, and you may have productive agriculture, the arts may flourish, architecture may cover your land with temples and palaces—you may even have material power to defend and support all these acquisitions; but, if the population of the country is stationary, or yearly diminishing in number, it diminishes also in stature and in strength—that country is doomed. Speaking to those who I hope are not ashamed to say they are proud of the empire to which they belong, and

which their ancestors created, I recommend them by all the means in their power to assist the movement which is now prevalent in this country to ameliorate the condition of the people by improving the dwellings in which they live. *The health of the people is, in my opinion, the first duty of a statesman.*"

Mr. Gladstone, addressing a gathering at Hawarden in August, remarked that he had "lived in the West End of London for forty-six years, but although there is a greater number of people there, and the town has spread in all directions, yet when you open a window now the air is purer and fresher, and fewer 'blacks' come in, than 40 years ago. The reason is that Acts of Parliament have been passed to prevent people from wantonly and wilfully making smoke, and compelling them to consume it. This is now done to a great extent—*not quite so much as it ought to be*, but still a great improvement has been effected. God made this world to be pleasant to dwell in. I don't mean to say He made it to be without trial or affliction, but He made our natural and physical condition to be pleasant. The air, the sun, the skies, the trees, the grass, and the streams—these are all pleasant things; but we go about spoiling, defacing, and deforming them. We cannot, it is true, make the town as pleasant as God has made the country, but most of you can do something to prevent the pleasant things which have been vouchsafed to us from being deformed and defaced by the hand of man in the future."

COSTLESS VENTILATION, by P. Hinckes Bird.

Mr. P. H. Bird, formerly of St. Thomas's Hospital, describes his method of ventilation as follows:—"Simple, economical, and free from draught. The lower sash of the window should be raised, and place in front of the

opening at the bottom rail a piece of wood, from two to three inches in depth. This leaves a space in the middle of the window, through which the air is directed towards the ceiling; the air is driven so high as to be warmed before it descends. The more the lower sash is raised, the more the difficulty of blacks entering between the meeting rails is increased. The principle may be modified, by making the bottom frame of wire blinds supersede the strip of wood, or if this be placed above, and the top sash drawn down to a corresponding depth, the same result will obtain; in a word, open the lower sash of the window two or three inches and block it up anyhow, and the air enters the space in the middle and is carried to the ceiling.

"The opening between the meeting rails admits more air than the various patented plans applied to the top of the sash; with the constant current of fresh air which the adoption of this plan will produce inwards, occasionally there is a passage of heated air outwards. In such a case the latter is always at the sides of the window, and the fresh air finds admittance at the centre. Provision, however, should always be made for the escape of heated foul air through a large valvular opening in the flue or elsewhere. This method may be adopted in any weather, by day or night, either in summer or winter.

"At night, when gas is burning, I adopt the following plan:—At 6ft. 6in., place a small hook in the moulding of the shutter-case *farthest* from the window on each side, and another two inches *below* the moulding on each side in front of window-sill; *tightly* stretch across the window a length of linen or calico, with small loops or rings to attach to the four hooks, leaving the calico nine inches larger than required to hang down loosely on each side. Throw up the lower sash as required, and draw the blind down to the lower rail of the window-sash, wherever it may be. The air enters in full volume, strikes against the broad surface of the calico, and is directed upwards towards the ceiling."

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